PROFESSIONAL LEARNING TO NURTURE ADAPTIVE TEACHERS

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ABSTRACT

This paper presents the findings of a study conducted in China to identify the potential benefits of incorporating robotics as an educational tool for 100 primary and 320 secondary school teachers of general technology. The Professional Learning Program was conducted from 2010-2013 in China. The major focus of the program was on the development within the teacher participants of knowledge, attitudes, habits-of-mind, skills and confidence necessary for the successful enactment of the curriculum reforms. It aimed to facilitate the development of *adaptive expertise* in using technology to facilitate innovative teaching and learning in Chinese classrooms. The study found that teachers made substantial progress towards the development of adaptive expertise as manifested not only by advances in the teachers' repertoires of pedagogical content knowledge but also in changes to their levels of confidence and identities as teachers. Although the study occurred in China, many of the issues with respect to professional learning by teachers are not unique to China. Thus many of the key issues identified in this study have wider implications for professional learning programs in other countries introducing student-oriented reforms in schools.

KEYWORDS

Professional learning, robotics, adaptive expertise, innovation

1. INTRODUCTION

In promoting a new culture of learning Thomas and Brown (2011) emphasised that teachers need to realise that 'to learn means to embrace what we don't know, come up with better questions about it, and continue asking questions in order to learn more, both incrementally and exponentially. This means that teachers are in fact giving less to students but expecting them to think more and construct their own knowledge'. This philosophy formed the basis for the design of a Professional Learning Program that was conducted with 420 Chinese teachers to successfully cultivate their skills to creatively solve problems, enhance creativity levels in students, and allow teachers to be comfortable in sharing this expertise with their peers. When teachers in China are given this opportunity for professional learning, they are introduced to new technologies and tools for teaching and learning that can subsequently support a significant change in teaching practices and facilitate a change in teacher mindset.

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 a thorough overhaul of the way education is delivered, examined and administered. It stated that the general education system would:

- be an integrated development where everyone can become a talent;
- combine learning and thinking;
- unify knowledge and practice;
- allow teachers to teach according to individuals' needs; and
- reform education quality evaluation and personnel evaluation systems focusing on performance including character, knowledge, ability and other factors.

In order to achieve a successful enactment of the curriculum reforms mentioned above, the major focus of the Professional Learning Program (PLP) was to develop and nurture within the teacher participants their knowledge, attitudes, habits-of-mind, skills and confidence to allow them to implement change within their own schools.

ISBN: 978-972-8939-99-1 © 2013

2. CONTEXT OF THE STUDY

Research increasingly has shown that the continued professional development of teachers is the key to improving the quality of education. Experience in many countries strongly indicates that many educational reforms rely on teacher learning and improved pedagogical practices in class to enhance student learning (Borko, 2004). Numerous studies and reports have recommended changes to teacher education to better prepare them to cope with 21st Century students (Kalantzsis & Cope, 2008). Due to recent New Curriculum reforms in China, in-service teachers urgently need to engage in an "effective" kind of professional learning, if the newly introduced educational reforms are to have an impact on student learning. Lawless and Pellegrino (2007) argue that introducing teachers to new technologies for teaching and learning can support a change in teaching practices. The Professional Learning Program (PLP) demonstrated not only how to use technology, but also showed the teacher participants how technologies can support instructional goals implicit in the current curriculum reforms. The PLP sets out to achieve a degree of change in teacher mindset and habits-of-mind. The activities involved the use of LEGO® educational toolsets. However, no previous familiarity with LEGO® robotics or terminology was assumed.

LEGO® educational toolsets were used because research studies have shown that robotics can have inter-disciplinary potential to enhance cognition in a range of ways. Research on the cognitive skills development associated with technology has established that use of robotics helps improve students' problem solving skills, critical thinking, collaboration and communication (Barker & Ansorge, 2007). Maud (2009) discovered through extensive use of robotics-based lessons that students were simultaneously developing knowledge in mathematics and science and being required to vocalise problems and solutions. Working with technology-based processes of design also encouraged peer-tutoring, self-reflection and self-directed learning.

The activities within the PLP encouraged a culture of knowledge-building, collaboration and teamwork. The activities pushed teachers 'out of their comfort zone' to facilitate their development as 'adaptive experts' actively engaged in hands-on activities focusing on the development of problem-solving skills. 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 procedural competencies, models of practice, and ways of monitoring their own development (University of Minnesota, 2010).

Teachers with adaptive expertise also exhibit the disposition of reciprocity; they are more able to move beyond their identities as science, technology, engineering or mathematics teachers and be buoyed by a sense of discovery and enjoyment at interacting with others who come from a different perspective (Hardy, Howes, Spendlove & Wake, 2008). These teachers also display a willingness to go outside of their own discipline area and engage in joint learning tasks with teachers from other disciplines, express uncertainties and ask questions, take a variety of roles in joint learning enterprises and take others' purposes and perspectives into account. This teacher attribute probably is a necessary condition for the successful implementation of trans-disciplinary 'intellectually messy' learning situations (Lantz, 2009).

2.1 Theoretical Framework for the PLP Design

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 GT syllabus for this project
- *Active learning*: opportunities for teachers to engage – throughout the PLP, GT teachers had ample opportunity to engage whereby they designed challenges, discussed, evaluated, reflected and shared their knowledge online.
- *Coherence*: the consistency of school, district and state reforms and policies with what is taught in the PLP – this project was sponsored by the Ministry of Education with industry support and policy messages to teachers were consistent throughout.

- *Duration*: PD activities require sufficient time and had to span over a semester – the PLP was conducted intensively over five days, followed by implementation in schools and follow-up workshops after twelve months.
- *Collective participation*: participation of teachers from the same school or department – in the PLP teachers were grouped according to provinces and engaged in multiple forms of interaction and discourse including extensive group work and online discussion forums.

In addition, four pedagogical approaches (Goldman, Eguchi & Sklar, 2004) were adopted. Firstly, the program was underpinned by the theory of constructivism where human learning is constructed. Learners build new knowledge upon the foundation of previous ones. No matter if they are correct or incorrect, despite having the same learning experience with somebody else, each learner constructs individual meanings. Secondly, the notion of Papert's (1980) constructionism – learning by doing -- was incorporated. The learner in a constructionist environment builds things on their own, preferably a tangible object that they can both touch and find meaningful. Thirdly, learning by design facilitated collaborative learning in teams whereby students engage to design activities and reflect on their experiences. Fourthly, cooperative inquiry, which involves -- contextual inquiry, participatory design and technology immersion – allowed for teacher exposure to LEGO® robotics which for many teachers in China was their first experience. The PLP placed heavy emphasis on pedagogy. It was not sufficient for teachers to merely engage in exciting activities, work with well-developed curricular materials, and interact with one another in constructive and positive ways. The PLP aimed to have teachers return to their classrooms with clear teaching methods and means to assess their students' learning processes.

2.2 The Three Phases of PLP Implementation

The three phases (Table 1) of implementation were:

Phase 1: Three and a half days face-to-face training: teachers participated in hands-on workshops focusing on inquiry and project-based learning using LEGO® robotics and the 4Cs approach – Connect, Construct, Contemplate, Continue - (the socio-constructivist 4Cs model which is the philosophy behind LEGO® Education tools). At the end of the PLP, each teacher was required to design at least three more lessons, which they will try out once they have returned to their own schools. These lesson plans together with teacher self-reflections and notes for improvement were uploaded online for sharing.

Phase 2: Twelve months of lesson implementation in schools and continual reflection: teachers implemented their ideas in their classrooms, using some of the strategies derived in Phase 1.

Phase 3: Two-day follow-up workshop focusing on reflection and sharing. 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.

Table 1. The three phases of the PLP

Phase	Name of Phase	Period	Activities	Focus
1	Initial Training	3.5 days	▪ Lectures/Presentations and Open Forums (Plenary Group of teachers) ▪ Workshop and Reflection Sessions (Four Workshop Groups split into teams of 3-4 teachers from same region) ▪ On-line Moodle® discourse	▪ Inquiry and project-based learning with LEGO® Education Toolsets (4Cs approach) ▪ Establishment of knowledge-building professional learning community
2	Implementation	1 School Year	▪ Application in schools ▪ On-line reflections and discourse	▪ Determining how inquiry and project-based learning can be implemented in Chinese schools.
3	Sharing/Reflection	2.5 days	▪ Presentations: ⌗ Seminars ⌗ Workshops	

The teachers were expected to think technologically (using LEGO® robotics across subject areas) to investigate, design, produce, evaluate and reflect on their design challenges. They engaged continuously in discussions both in class and online which focussed on the interplay between materials, systems and information in the tasks which they carried out in teams of four or five. 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 professional learning program, each teacher was required to design at least three more lessons, which they would try out once they returned to their own schools.

3. FINDINGS

3.1 Impact on Teachers

The analysis of data revealed that during the implementation phase of the PLP, the teacher participants had consolidated and in most cases advanced to their levels of adaptive expertise as indicated below:

Pedagogical Content Knowledge: The analysis of data clearly indicated that the socio-constructivist 4Cs model (philosophy behind LEGO® Education tools) had become a central component of most of the teacher participants' pedagogical knowledge.

Habits-of-mind and Attitude: The analysis of data from the Reflection/Sharing Phase of the professional learning programs indicated that the teacher participants had adopted habits-of-mind and attitudes about teaching, learning and assessment consistent with the LEGO® 4Cs approach and those implicit in the National Plan (PRC, 2010).

3.2 Impact on Teaching Methods/Approaches

All of the teacher participants interviewed indicated that since their participation in Phase 1 of the PLP, they had made significant changes to their teaching methods & approaches when they returned to their own schools. These major changes were detected. Firstly, teachers introduced group work and group exploration for students. Secondly, teachers adopted problem-solving approaches based on the 4Cs' concept for their lessons. Thirdly, teachers increasingly adopted and adapted interactive teaching/learning strategies hitherto not frequently utilised in their classrooms such as open-ended focus questions, discussions about how and what had been learnt, and reflection on how the process and product could be improved and assessed.

3.3 Impact on Teacher Vision

During the interviews, most of the teacher participants from the PLP indicated that they felt that a major impact of the programs that had been reinforced during the one school year period of the implementation phase had been changes to their vision as a teacher. This vision tended to focus on the educational significance of the LEGO® 4Cs approach and the vision of a teacher being a nurturer of student creativity.

3.4 Impact on Other Teachers and Educational Administrators

The impact of the PLP on teachers was amplified by the 420 teacher participants in the professional learning programs engaging in the professional development of other teachers in their schools and/or teachers from other schools in their city/region. Thus, in many cases the application of LEGO® Education Toolkits often went beyond the subject areas of the teacher participants.

3.5 Impact on Students

Despite the constraints that the teachers had to work with in their local situation, the findings strongly indicated that the PLP had a flow-on effect to students in the classroom. The analysis of data indicated that the teacher participants felt that the introduction of the student-oriented LEGO® design challenges and the

implementation of the teaching/learning strategies they had acquired from their participation in the professional learning program into their schools had had the following six positive effects on their students:

- Arousal of interest;
- Recognition and utilisation of individual students' abilities;
- Increased innovative and divergent thinking;
- Increased risk-taking and perseverance;
- Enhanced teamwork and life skills; and
- More active learning.

The above effects were clearly evident in the responses from the perspective of teacher participants during interviews.

3.6 Issues and Problems

Two types of issues and problems faced the teacher participants during the implementation phases of each of the PLP. A minority of teacher participants indicated that they were still under pressure from parents and administrators to cover content while trying at the same time to implement socio-constructivist teaching/learning practices in their classrooms. However, pragmatic issues and problems such as:

- logistical problems – insufficient LEGO® Kits, no replacement parts
- class sizes; and
- administration shortcomings - procurement problems, timetabling, school policies, disparity between affluent and less affluent remote schools were perceived by most of the teacher participants as being the major impediments to the successful implementation and further advancement of the teaching/learning reforms in their classrooms. The set of recommendations presented in the following section addresses most of these conceptual and pragmatic issues and problems.

4. RECOMMENDATIONS AND FUTURE DIRECTIONS

Two sets of recommendations will now be presented. The first set of recommendations focuses on what needs to be done by the government authorities at the national level and what needs to be done at the local level by regional administrators, principals and subject coordinators to reinforce, extend and amplify the beneficial outcomes from the professional learning programs. The second set of points focuses on the design and implementation of future professional learning programs and possible future research.

4.1 Building upon Outcomes of the PLP

Many teacher participants in the PLP reported that the major impediments to the full and successful implementation of the socio-constructivist teaching and learning practices were due to pragmatic issues and problems. In order to address these pragmatic issues and problems, the following recommendations are made:

Recommendation 1: That teachers who have participated in the professional learning programs be strongly supported in their schools by the provision of school policy, procedures and timetabling that support the implementation of the reforms.

Recommendation 2: That schools empower their teachers to lead and drive change, and create opportunities for their students to learn in new ways to meet their individual needs. Classrooms should support new approaches to learning, not only through the use of LEGO® Education Toolkits but also through changes in the culture of the school. For these practices to be championed in schools, all stakeholders need to work together to progress the school reform agenda.

Recommendation 3: That all levels of administration (school, region, and central government authorities) ensure that each classroom is provided with ample number of LEGO® Education Toolkits to enable teachers to establish collaborative learning groups of 2-4 students within their LEGO® design challenge lessons.

Recommendation 4: That the government authorities enable schools to purchase at reasonable cost replacement parts for LEGO® Education Toolkits lost through wear-and-tear, breakages or theft. The process of procuring these replacement parts should be made easily available online and when immediately needed by the teachers.

Recommendation 5: That ongoing professional learning be provided. The completion by teachers of the professional learning programs should be accompanied by continued and renewed efforts to strengthen and reform how lessons are taught in schools in China and in particular how technology is integrated across the curriculum to achieve enhanced outcomes for student learning. Failure to provide follow-up on the professional learning programs is a false economy that will significantly minimise the sustainability of the curriculum and teaching/learning reforms ushered in by the professional learning programs.

Recommendation 6: That the authorities establish an online platform to encourage teachers to engage, collaborate and share their teaching and learning beyond school level (e.g., to local provincial level or national level) to ensure that ongoing/sustainable professional learning occurs.

4.2 Future Directions and Conclusions

A number of important implications for the design and implementation of future teacher professional learning programs in China has emerged during the course of the four professional learning programs in this project. The points to note for future programs are:

Point 1: Professional Learning Programs need to be carefully designed and customised for local conditions. This is to ensure that "cultural synergy" (Jin & Contazzi, 2001) occurs during the course of the professional learning programs. With cultural synergy, there is mutual effort from teachers and facilitators from different cultural backgrounds to learn about, understand and appreciate others' culture and their interpretations of learning and to learn reciprocally with and from others.

Point 2: Professional Learning Programs need strong conceptual and theoretical frameworks otherwise they are in danger of becoming a 'one-shot' fix and their outcomes and impact will not be sustainable in schools.

Point 3: Participant group size: the optimal group size for future professional learning programs should be set at maximum of 28 participants to allow for meaningful group work and group dynamics during discussions and reflection sessions. It is not about economy but quality of the professional learning. A particular strength of the PLP was getting all the teachers (from 32 provinces) to come to one venue in one city and engaging them in a highly focused PLP.

Point 4: Selection of teachers: teachers need to be fully informed about why they are attending and not simply sent by the school or at the direction of the authorities without any background knowledge. (Facilitators need to know the teaching backgrounds of teachers well in advance).

Point 5: Careful selection of participants by school principals of teachers with the attributes (status with teaching peers, experience, openness of mind, school "gate-keepers") necessary to not only understand and take on the reforms in lesson design and implementation presented in the professional learning programs but also to enthusiastically facilitate the adoption of these reforms by other teachers in their schools and regions.

Point 6: Senior administration needs to be involved and preferably participate in the professional learning programs. If this is not possible, half-day training sessions for senior school administrators on the theoretical underpinnings of the professional learning programs is recommended. Another necessary condition is for senior administrator "buy in" too.

Although the project occurred in China, many of the issues with respect to professional learning by teachers identified during the course of the PLP are not unique to China. Many other countries (e.g., other Asia-Pacific rim nations such as Singapore, Korea, Vietnam, Malaysia, and Japan) are currently engaged in reforms similar to those in China (Drori, 2000; Los Angeles Times, 2012; Tan & Gopinathan, 2000) in order to cope with the effects of globalisation. A review of the literature indicates that these countries are experiencing problems similar to those being experienced in China (see Coll & Taylor, 2008; Poisson, 2000). Thus, many of the key issues identified and reported in this project have implications for professional learning programs in other countries engaged in the process of introducing into their schools "student-oriented" reforms in science and technology education.

We hope that the set recommendations and point to note presented in this paper will provide strategies that can be implemented in future to improve the level of integration of LEGO® toolkits across curriculum areas in Chinese classrooms and perhaps in many other countries as well. These findings also lay the foundation for future research on PLPs conducted in similar settings.

ACKNOWLEDGEMENT

The author wishes to acknowledge the support of LEGO Foundation, Semia Ltd. Beijing and the Chinese Ministry of Education for providing the funds for this project. Special thanks are due to the project team and all the teachers in China who engaged with an open mind and enthusiastically participated in all aspects of the program.

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