

## Learning to Teach and Teaching to Learn: Improving Practice in the Mathematics Classroom through Lesson Study

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### *Abstract*

*Teachers are still the most important asset of the school that influences students' performance. Teacher professional development is therefore essential for any curricular reform to be successful. This paper looks into Lesson Study as one possible model for Continuous Professional Development (CPD) and compares it with action research. The paper further discusses a pilot project on Lesson Study carried out to investigate its suitability as a school-based CPD program. The pilot project was primarily aimed at using Lesson Study as an approach to assist teachers align classrooms lessons to new features in the Malaysian curriculum that focuses on mathematical thinking. Initial findings showed positive reactions from both the teachers and the school leadership towards Lesson study. The teachers further showed improvement in lesson planning and their knowledge of the use of mathematical thinking and communication in their lessons. The pilot study showed that Lesson Study is a powerful model that can be used to guide teachers towards new practices geared at improving teaching and learning in the classroom*

### **Introduction**

There are a variety of reasons why people choose to become teachers. In Malaysia, for example, it is not uncommon for some more rural and conservative families to wish that there would be a teacher in the family. Yet others become teachers because they view teaching as a suitable profession for working housewives. Even in more developed countries, like in the United States of America, there is a concern for finding ways to attract quality teachers (Wallis, 2008) by providing for better enumeration. With the varied reasons teachers have for becoming teachers, it can be reasoned that the motivation for teachers to improve their own teaching will therefore be just as varied. Yet it is now commonly held that teachers should continue to improve on their own knowledge and skills in order that students' performance can subsequently improve on the performance (Hill, Rowan & Ball, 2005). Acquiring teaching skills and knowledge do not end when the teachers qualifies from preservice teacher training. On the contrary, the initiation of the teacher into school life marks the beginning of a long journey of continuous professional development (CPD).

Teaching is a rather unique profession. Even before enrolling for training to qualify as teachers, prospective teachers already know what classroom teaching is like. Unlike many other professions, the teacher's workplace is not unknown to the prospective teacher. Most likely the teacher would have would have built images of how teaching would be like based on her experiences as a student. While this may be advantageous for the prospective teacher, it sometimes brings along images of undesirable practices that

would be difficult to remove. Thus improving teachers' instruction is not an uncomplicated task. Preservice teacher education therefore marks not the end but the beginning of the task of molding better teachers. One of the tasks in this endeavor would be to continuously develop teachers' knowledge. Granted that preservice training primarily aims at providing teachers with the basic knowledge for teaching, CPD then complements to further and continuously develop teachers' knowledge and skills.

### **Continuous Professional Development**

#### *Teachers' Knowledge*

One of the watershed ideas about teachers' knowledge was elaborated by Shulman (1987). The knowledge base for teachers should include:

1. Knowledge of the subject to be taught
2. General pedagogical knowledge
3. Curriculum knowledge of materials and programs
4. Pedagogical content knowledge, the "special amalgam of content and pedagogy"
5. Knowledge of students
6. Knowledge of educational contexts
7. Knowledge of educational ends, purposes and values

A closer look at these different areas of teachers reveals that although it is possible to expose teachers to the various types of knowledge during training courses, most of it will however need to be acquired while in practice. Pedagogical content knowledge and knowledge of students needs to be constructed and acquired over time through persistent reflective observations.

#### *Cascade and School-based CPD*

Teachers are still the most important asset of the school that influences students' performance. For teachers to improve instruction, it is necessary to assist teachers by having a well structured continuous professional development program. In some countries, for example in Southeast Asia, national guidelines have been drawn up to encourage continuous teacher development by mandating that teachers spend a minimal stipulated time in CPD. In order to achieve its goals, the main aims of CPD would be to develop teachers' knowledge, skills and attitude in order to handle the complexities of the classroom. There are two main ways which CPD is normally organized; through the cascade model and the school based approach.

In countries that use a national curriculum, the cascade approach for CPD is a popular way of disseminating curricular changes. In the cascade model, the first level of training targets at the national level master trainers who then conduct training for teachers at the provincial or district level who in turn train more teachers at the school level. In this approach there is the expectancy of a cascading effect of knowledge from the central agency down towards the teachers in schools. This approach is popular as it is deemed most efficient and cost effective in reaching out to the most number of teachers. However, there are two main disadvantages. First, in the cascading effect the amount of information and knowledge that is transmitted also diminishes by the time the training reaches the school teachers. Often the cascading effect ends up as a trickle by the time it reaches the classroom. Second, the school teachers do not have ownership of the curricular change

making implementation difficult and consequentially the curricular change being not implemented effectively. Thus, this leads to the resulting gap between the intended and the implemented curriculum.

### *Action Research*

In school based teacher development programs, teachers form groups in schools to manage their own professional growth. It offers the advantages that are not found in the cascade model. The school based model shifts the ownership of development to the teachers. Development then becomes more context sensitive, collaborative and reflexive allowing teachers to manage their own professional growth. School-based teacher development programs are conceptualized in a variety of ways which may include in-house seminars, invited speakers and peer sharing of materials from courses attended. Action research is also one of the ways which teachers use in school-based CPD. It differs from the tradition of normal research as it begins not by framing the research question and then setting a situation to collect and analyze data but rather from the middle of daily practice. There are two main purposes of carrying out action research: 1) to serve as a professional development program, and 2) to act as a means of knowledge production (Zeichner, 2001). Zeichner (2001) further noted that there are various ways action research have been included in CPD in schools. Teachers conduct action research alone, in small collaborative groups or in subject-based groups in school and sometimes with external facilitators. There are various models for actions research which follow the well-known action-research cycle: plan, act, observe and reflect (Elliot, 1991; Kemmis & McTaggart, 1988; McNiff, 1997). Based on the aims and the research methodology used, action research can be classified into three main categories: scientific, practical deliberative and critical emancipatory (Green, 2001). From the historical perspective, there seems to be a gradual move away from a quantitative towards a qualitative research methodology in action research. Corey's model of action research, for example places emphasis on the distinct phases of (1) Identification of the problem area and the selection of a specific problem and the formulation of hypothesis and prediction of the desired goal, (2) Careful recording of actions and accumulation of evidence, (3) Making inferences regarding the relation between the actions and the desired goal, and (4) the continuous retesting of the generalizations (Corey, cited in Zeichner, 2001). The later models of action research for example, the Practical Deliberative and the Critical Emancipatory were more qualitative in the research methodology. Similarly teachers, the main practitioners in educational action research have taken on more participative and emancipatory roles in the practical deliberative and critical emancipatory types of action research. Table 1 summarizes the comparison of the three types of action research.

### *Action Research in Malaysia*

Action research was first introduced in Malaysia as part of the Program for Innovation, Excellence and Research (PIER) in 1993. The main trust for PIER was to improve four main educational areas: Innovations in science and mathematics, small and isolated schools, distance education and educational research. It has been reported that action research continues to be one of the trust of the Ministry of Education (MOE) with the setting up of research committees at the State Education Department and action research groups at the state level (National Institute for Educational Policy Research, 2006). At present an annual research seminar is organized for teachers to showcase and to share the action research projects (Educational Planning and Research Division, 2007).

To further improve the action research program in school the MOE suggested 1) Increasing the financial allocation for this program, 2) Introduce the management of change training for school administrators, 3) Improve monitoring mechanism, and 4) Developing training modules such as standardized training procedures and processes so that teachers who have not been given the opportunity to attend courses can use these materials for their project (National Institute for Educational Policy Research, 2006).

Table 1  
*Types of Action Research*

	Scientific	Practical Deliberative	Critical Emancipatory
Research approach	Based on the scientific research approach, more measurement and control. More quantitative approach.	Less scientific, more human interpretation, collaboration and communication. More qualitative approach	Aimed at providing teachers with skills to make sound decision. More qualitative approach.
Flow of the action research from one cycle to the next	Logical flow from an orderly research process.	No rigid control, new information studied and examined carefully. Require teacher's deep reflection.	Simple model of planning acting, observing and reflecting. Reflection leads to revise plan.
Focus of the Research	Focus on the research product	Focus on the process	Focus on the process
Example	Lewin, Corey	Elliot	Kemmis and McTaggart

These suggestions indicate that thus far efforts to promote action research have been mainly using the top-down approach primarily sponsored by the MOE. Although there have been great effort in promoting school-based action research, there are two issues that need to be addressed in order that the action research program in Malaysia can be further sustained and made relevant to school teachers:

1. Research report writing is not one of the forte of school teachers. Moreover it is not a task that teachers do daily in school. Clearly if the present form of action research is to be further emphasized and continued then much more effort is needed to train the teachers in report writing and research methodologies.
2. There is a need for teachers to focus on ways to improve in the classroom instruction as conceptualized in the curriculum. The Malaysian mathematics curriculum has been revised to make mathematics learning more interesting and meaningful (Curriculum Development Centre, 2006). The current curriculum now focuses on the use of mathematical processes in classroom didactics. Instead of using of action research to investigate a wide variety of problems, some of which may entail looking at issues outside the purview of the teachers, there can be more effort focused on assisting teachers implement the curricular changes in the classroom which would then be a more relevant exercise for teachers.

*Lesson Study*

The *Lesson Study* (LS) is another CPD model that shows many features that are similar to action research. The LS however did not develop from the earlier traditions of action research rather it emerged from the Japanese practice where teachers would come into a fellow teacher’s classroom to observe the lesson. The post-lesson discussion is then conducted primarily to find ways to improve the lesson. This plan-do-see-improve cycle thus shows congruency to the action research cycle.

LS was first introduced in Japan in the late nineteenth century. Its main purpose then was to help teachers move from individualized towards whole class instruction. The focus of LS in Japan has since shifted towards using open-ended problems in student-centered mathematics classrooms by the middle of the twentieth century (Isoda et al., 2006). LS has since spread to other countries with some success (Department of Education and Training, 2003; Lewis, 2004). LS is similar to action research in many ways, however in LS primary focus is given towards the area of classroom pedagogy mostly on subject matter. Lewis (2004) described the following as essential characteristics of LS in Japan: (1) A long-term goal shared by practicing teachers, (2) A focus on the importance on lesson content, (3) Careful study of student learning and development, and (4) Live observations of research lessons. Lewis (2004) further posits that in the Japanese LS model, the teachers seeks to improve by focusing on the goals of classroom lesson and long-term goals for the students, deepening teachers knowledge of subject matter, developing instructional expertise and developing “the eyes to see children [*kodomo wo miru me*]”. Primarily then the focus of LS is to improve teaching so that it is aligned to the intended curriculum. This is in contrast to action research which focuses on a wide variety of school related issues. In action research, the practice is for the teachers to explore and identify the research problem from a wide variety of issues related to teaching. From this perspective LS has more direct relevance to teachers as it focuses on the core business of teachers; to teach and to improve teaching the lesson. Table 2 summarizes the similarities and differences of LS and action research.

Table 2  
*Comparing Action Research and Lesson Study*

	Action research	Japanese Lesson study
Research domain	1. Within classroom, 2. Beyond class room but within school 3. Beyond school	Within classroom
Research questions	A wide variety of school-related issues focusing on: 1. Improving teaching 2. Understanding classroom practice 3. Producing useful knowledge 4. Promoting equity 5. Influencing social conditions of practice	1. How to improve long term goals for students 2. What should be the goals of particular content area? 3. How to develop instructional expertise? 4. How to build capacity for collegial learning? 5. How to “look through the eyes of the students”?
Research Cycle	Plan-Act-Observe-Reflect	Plan-Do-See-Improve
Data collection	Journals, observations, surveys, interviews, document analysis.	Lesson plan, observation notes, post lesson discussion, lesson video
Sponsors	1. Teachers	1. Teachers

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- |                                   |  |
|-----------------------------------|--|
| 2. Local and national governments | 2. University attached schools                                   |
| 3. School districts               | 3. Partnerships: school teachers, university, Board of education |
| 4. Colleges and universities      |  |
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### **A Pilot Project on Lesson Study**

This project was conducted to pilot the LS approach to address two main concerns in the teaching and learning of mathematics in Malaysian primary schools. First is the concern that the teaching of mathematics in the country is still very much focused on computations and pupils often learn mathematics mainly by rote. This practice often leads pupils to not being able to appreciate, meaningfully understand and subsequently apply the mathematical concepts in solving problems. The aim was thus to help teachers align the mathematics lessons to the revised national curriculum (Curriculum Development Centre, 2006) which advocates pupils learning mathematics by engaging in mathematical processes like mathematical thinking, communication and problem solving. The second concern focuses on the pursuit to look for and further refine an approach that can be used to provide sustainable support for teachers in implementing the revised national curriculum. With a top-down teaching reform tradition in Malaysia, the challenge is therefore to actualize the implementation in the classroom so that it aligns well with the intended curriculum. This study thus attempts to explore the Lesson Study approach as a means to assist teachers collaboratively improve the mathematics lesson.

#### *Objectives of the Project*

The Pilot Project was planned with the following objectives:

1. To enable the teachers to experience how mathematical thinking can be incorporated into mathematical tasks.
2. To enable the participants to plan lessons focusing mathematical thinking and communications.
3. To enable the participants to carry out the lessons according to the lesson plan
4. To collaboratively analyze the video-taped lesson and to improve on the lesson plans

#### *The Project Plan*

Since both the LS approach and process-based mathematics lessons were new to the teachers, five workshops were organized between January and March 2008. The aim of the workshops was to introduce the key concepts of the project to the participating teachers: mathematical thinking, communication, lesson study and lesson planning. The workshop activities were hands-on and included activities where the teachers took part in mathematical problem solving, discussions based on videos showing the teachers how mathematical thinking activities can be integrated into the lessons and videos showing the lesson study process from Japanese and Malaysian primary classrooms (Japan International Cooperation Agency, 2006). During the fourth and fifth workshops the teachers gathered in groups, with teachers from the same school in the same group, to discuss and plan the research lesson. It was found that the two workshops of two hours each did not provide enough time for the teachers to complete the lesson plans, so the lesson planning was continued by the teachers in their respective school with the assistance of facilitators from *Universiti Sains Malaysia* and *RECSAM*, after the first five workshops were held. Each group then chose a teacher from the group to teach the research lesson while the others observed. All the lessons which were carried out in May

and June 2008 were videotaped. Each of the lessons was planned for 40 minutes to one hour. However some of the actual lessons did not go as planned and took more than an hour to complete. For each group there was a post lesson discussion where the lesson was analyzed and suggestions were offered to improve the lessons. A final workshop was held in June 2008 where the teachers analyzed and discussed the lessons based on the lesson videos.

*The Project Participants*

Initially eight primary schools accepted the invitation to join the project and three teachers from each school attended the workshops. One more school joined the project later but by the end of the project there were six schools which were still involved in the project. Although the attrition rate seemed high, it was noted that the teacher participants joined the project on a voluntary basis with the support of the respective school head masters. The workshops were also planned in the afternoons only so as to avoid the teachers having to leave class to attend the workshops. It was therefore noted that the teachers participation in the project were an added extra to the already heavy workload of the teachers in school. It was further noted that teachers’ participation would not have been possible without the huge support and commitment given by the school headmasters. The commitment of the school headmasters and the teachers were crucial to the success of the project.

Table 3  
*Plan of the Lesson Study Pilot Project*

Dates	Workshops	Purpose of the Workshop
January - March 2008	Workshop 1 (2 hours)	Introduction to Lesson Study and workshop will focus on mathematical thinking
	Workshop 2 (2 hours)	Focus on teachers experiencing tasks that focus on mathematical thinking and communication.
	Workshop 3 (2 hours)	
	Workshop 4 ( 2 hours)	Lesson Planning
	Workshop 5 ( 2 hours)	Lesson Planning
April – May 2008	Actual lessons in school	Continuation of lesson planning followed by actual research lesson
June 2008	Workshop 6 (2 hours)	Analysis of lesson videos followed by discussions.

**Findings**

The pilot project adopted an interpretative approach and data were collected through questionnaire and interviews with the teachers and school principals. The research lessons were also videotaped. A questionnaire was completed by the teachers at the end of each workshop primarily to track the teachers’ reaction and the progress of the teachers’ learning.

### *Teacher's Reaction.*

Through the questionnaires and informal interviews it was seen that the teachers were initially positive about both the use of mathematical thinking in their lessons as well as about LS. When asked, "What features would you like to integrate in your lessons?" after watching the LS videos from Japanese and Malaysian classrooms, the teachers were able to relate the activities as well as identify features in the videos to integrate into their teaching practice.

*"Integrate daily life activities including games." "Student have the things (blocks) to find the answers then give the explanations; All the students pay attention, all students take part in group activities."*

The teachers were however also aware of the difficulties that they might face in real classrooms.

*"Yes, teacher must notice: all student can do it, control the students, take care about class discipline." "Yes, for small enrollment. No, if classroom is big. No, if pupils are of mixed learning ability."*

By the end of the project, all the teachers expressed confidence about using the LS approach.

*"L.S. is very helpful especially to those new teachers." "It is a very useful approach in the teaching and learning process which helps the pupils to think and answer the questions through their activities in order to get the concept of such topic." "No longer use teacher-centered method. But use ways that are fun and students can learn more deeply." "Yes. It would be very useful and benefit to our pupils by using this approach."*

### *Teachers' Learning*

*Lesson planning.* Writing lesson plans has been given much emphasis in the Malaysian teacher training program. However writing lesson plans has become routine where the teachers would extract the lesson objectives from the national curriculum and then fill in the lesson plan with activities from resource books and textbooks. Thus the teachers initially found it difficult to plan activities that could help the students think mathematically. Group planning was helpful, as the teachers began to build on team members' ideas, adding and refining until a final activity was created. Further the post lesson discussion helped the teachers see what did not work and thus they were able to modify the lesson.

*Teacher discussion.* The teachers also found that teacher discussion was an important part in learning to teach. *"Through lesson study teachers get to learn knowledge and new techniques for teaching." "By exchanging views and ideas about teaching and learning among colleagues."*

*Mathematical thinking.* From the lesson planning sessions it was observed that the teachers found it difficult to create mathematical thinking activities. Several of the teachers further spoke on the need to attend more courses on mathematical thinking. Some suggested that there be modules on mathematical thinking and communication. From these observations it was inferred that the teachers have become aware of the importance and the need for them to learn more about of the use mathematical processes

in the classroom. However the teachers felt that they still do not possess adequate knowledge on the use of mathematical thinking in the lessons.

### *School Support*

The support of the school headmasters and administration played a vital role in the success of the pilot project. In order that LS was able to be carried out in the schools, there were interruptions in the class time-table as it was difficult to find a common time when all the participating teachers were available. Thus relief teachers had to be arranged so that the all the participating teachers were able to observe the research lesson. There were thus added administrative work for the schools but the headmasters indicated that they were supportive of the pilot study because it was a good idea to have the teachers plan the lesson together as was expressed by one headmaster:

*“... There they sit, discuss, they share the ideas then they may .... they get more knowledge how to teach the activities. What type of activities they can teach. It is a good idea. Very good idea...”*

Although the headmasters were positive about LS, they also pointed out that there were be two major constraints to the implementation of the LS approach: 1) the need to change the teachers’ mindset, and (2) the time constraints as is required by the teachers to plan, observe and review the lesson collaboratively.

### *Teachers’ Use of New Knowledge and Skills.*

*Lesson planning.* One of the most evident improvement was the teachers’ ability in designing new activities that require the students think and investigate mathematically. Although there were many activities available in books and through the internet, the teachers did not want to use them as they were not directly correlated to the curriculum. Further the teachers did not feel comfortable using investigative mathematics activities that would take a long time. Through the collaborative planning together with fellow teachers and facilitators, the teachers were able to use new ideas to either create or improvise on teaching activities.

*Mathematical thinking and communication.* While the teachers were able to create classroom tasks that can be used to generate mathematical thinking, it was observed from the lesson videos that there were still more knowledge and skills that the teachers need to learn so as to be able to create mathematical discourse in the classroom. During the lessons, there was a lack of questions that require the students to explain the reasons behind their answers. The teachers were yet to be able to move the students into thinking deeper about the mathematical ideas and concepts. The teachers realized this and voiced that it would be helpful to have more assistance

*“Hope that the facilitators will continue to guide us.” “Module about mathematical thinking and communication.” “Need more knowledge of mathematical and mathematical communications. Try to have the workshop during school hours.” “module about mathematical thinking.”*

## **Conclusion**

Malaysian teachers follow a centralized curriculum. Past mathematics education reforms have therefore been traditionally carried out top-down using the cascade model of professional development. While this method has the advantage of being able to reach out more quickly and to more teachers, there are however certain drawbacks. Effective reform demands that there be more teacher support so that curricular changes can be effectively translated into real classroom practice. The collaborative nature of lesson study approach offers the much needed support for teachers to assist them in professional development and thus provide a potentially useful and sustainable method of CPD.

### *Emerging Issues*

Lesson study is still in its infancy in Malaysia. The initial findings from the pilot study however show the potential of LS as a practical CPD program both for teacher development and as an approach to support curricular reforms. The pilot study has however revealed some emerging issues that need to be addressed in order that LS can be implemented on a bigger scale in Malaysia.

1. *Formal structure for LS in school.* Mindful that education in Malaysia is centralized with a national curriculum, sustainable curricular changes would need to consider placing these changes as a formal program within the structure of the school. Yet as has been seen so often in the past, an approach which is entirely top-down without collaboration and cooperation with the teachers seldom achieves success in the long-term. Moreover a successful LS program demands the commitment of all the teachers involved. There is thus a need to place lesson study as a formal CPD program but with the voluntary cooperation of the teachers through collaboration and discussion.
2. *Time for meeting.* Collaboration among the teachers in the groups is one of the key features of LS. This however meant that there is a necessity to schedule meeting time to collaboratively plan and discuss about the lessons. Moreover there is also a need to find a common time in the time table in order that the research lesson can be carried out. This lack of time to carry out lesson study was one of the constraints expressed by both the teachers and the school administrators in the pilot study.
3. *Teachers' workload.* This constraint of time becomes even more pressing as the workload of the teachers seems to be ever increasing. Using Lesson study or any CPD would mean an increase teachers workload. It is therefore important for teachers to have sustained motivation. While teachers may gain implicit motivation through the success of LS and students learning, external motivation can be gained through various form of recognition by the school.
4. *The need for external advisors.* Some teachers in the pilot project expressed a wish that the external advisors could continue with LS in their schools. This raises the need for the presence of able external advisors to provide support and advice for the teachers. This could also mean providing facilitation skills to the external advisors even before joining the Lesson Study groups.

Even after considering the various challenges posed by the emerging issues, Lesson Study remains a potentially powerful CPD approach in the mathematics classroom as it offers both professional development as well as improvement of the mathematics classroom which in the long term would lead to student improvement.

### **References**

- Curriculum Development Centre. (2006). *Integrated Curriculum for Primary Schools: Curriculum specifications – Mathematics*. Putrajaya, Malaysia: Curriculum Development Centre, Ministry of Education.
- Department of Education and Training. (2003). *Lesson study project: Evaluation report*. Ryde, NSW: Department of Training professional support and Curriculum Directorate.
- Educational Planning and Research Division (2007). *Bahan kursus kajian tindakan 2007* [Action research course material 2007]. Retrieved on 12 September 2008 from [http://apps.emoe.gov.my/bppdp/kajian%20Tindakan%202007/index\\_kajian%20tindakan%202007.htm](http://apps.emoe.gov.my/bppdp/kajian%20Tindakan%202007/index_kajian%20tindakan%202007.htm)
- Elliot, J. (1991). *Action research for educational change*. Milton Keynes: Open University Press.
- Green, J. R. (2001). The development of a meaningful teacher evaluation process in a catholic elementary school. Doctoral Dissertation submitted to the Faculty of the Virginia Polytechnic Institute and State University. Retrieved on 16 September 2008 from <http://scholar.lib.vt.edu/theses/available/etd-11292001-11117/unrestricted/JeanGreen.pdf>
- Hill, H. C., Rowan, B., & Ball, D. L. (2005). Effects of teachers' mathematical knowledge for teaching on student achievement. *American Educational Research Journal*, 42(2), 371-406.
- Isoda, M., Stephens, M., Ohara, Y., & Miyakawa T. (Eds.) (2007). *Japanese lesson study in mathematics: Its impact, diversity and potential for educational improvement*. Singapore: World Scientific.
- Japanese International Cooperation Agency. (2006). *Teachers learning together: Japanese teacher training system and lesson studies*. Tokyo, Japan: Japanese International Cooperation Agency. (Video)
- Kemmis, S. & McTaggart, R. (1988). *The action research planner*. Geelong, Vic: Deakin University.
- Lewis, C. (2004). Does lesson study have a future in the United States? *www.sowi-onlinejournal.de*. Retrieved from [http://www.sowi-onlinejournal.de/2004-1/lesson\\_lewis.htm](http://www.sowi-onlinejournal.de/2004-1/lesson_lewis.htm)
- McNiff, J. (1977). *Action research: Principles and practice*. London: Routledge
- National Institute for Educational Policy Research. (2006). *Best practices in professional learning of science and mathematics teachers*. Tokyo: National Institute for Educational Policy Research (NIER). Retrieved on 12 September 2008 from [http://www.apecneted.org/resources/downloads/BestPracticeMSTeacher\\_NIER2005Nov.pdf](http://www.apecneted.org/resources/downloads/BestPracticeMSTeacher_NIER2005Nov.pdf)
- Shulman, L. S. (1987). Knowledge and teaching: Foundations of a new reform. *Harvard Educational Review*, 57(1), 1-22.
- Wallis, C. (2008). How to make great teachers. *Time Magazine 13 February 2008*. Retrieved on 16 September 2008 from <http://www.time.com/time/nation/article/0,8599,1713174,00.html>
- Zeichner, K. (2001). Educational action research: Participative inquiry and practice. In P. Reason & H. Bradbury (Eds.), *Handbook of action research* (pp.273-283). London: SAGE Publications.