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Lesson Study: A Potential Driving Force behind the Innovative Use of Geometer's Sketchpad

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This paper reports the vigor behind mathematics teachers' use of Geometer's Sketchpad (GSP) to teach secondary mathematics. It discusses the result of promoting pedagogical use of GSP among a group of mathematics teachers through Lesson Study (LS) collaboration. Data was collected through written lesson plans and interviews with individual participants. Teacher interviews reveal that LS enables teachers to learn new skills effectively despite time conundrum. These teachers indicated that collegial support is the motivating factor that sustains the LS process. Feedbacks from questionnaire and student interviews also reveal that students perceive positively the GSP learning environment. Although the result cannot be generalized, nevertheless it has demonstrated the potential of LS in capitalizing the power of GSP in mathematics teaching.

Key words**:** collaboration, lesson Study, geometer's sketchpad, technology.

Introduction

Schools in Malaysia in general have witnessed the phenomenon that school teachers place an over-emphasis on examination performance. The "finish-the-syllabus" syndrome is rampant as the demand of good result becomes the main concern for some mathematics teachers. Such circumstance will often compel classroom teachers to restrict their teaching to a lecture-and-drill method as noted by Shafer (2008).

Students nowadays are technology savvy and the chalk and talk approach has lost much appeal to these youngsters. Thus, there is a need for school mathematics teachers to change their teaching styles in order to keep pace with their students. *Geometer's Sketchpad* (GSP) is a type of dynamic mathematical software that explores geometry. GSP allows students to directly manipulate mathematical objects on the screen and therefore fosters mathematical inquiry about geometry (Finzer & Jackiw, 1998). Choi-Koh and Sang Sook (2000) claim that the dynamic multiple representations in GSP allow students and teachers to investigate their conjectures, thus enhance students-teacher interaction and improve their van Hiele levels of geometric thinking.

Hannafin, Burruss and Little's (2001) study on the grade seven students showed that GSP facilitates students' and teachers' visualization and exploration of mathematics concepts. They found that students enjoyed their new freedom, worked harder, and expressed greater interest in the subject matter that incorporates the use of GSP. Nurul Hidayah Lucy Bt. Abdullah (2005) found that 40 secondary school students who had undergone use of the GSP instructional program gained higher mathematics achievement scores and achieved higher geometric thinking levels as compared to their counterparts in the control group.

The Malaysia Ministry of Education has purchased the GSP license since 2004. It is envisaged that this project will benefit many teachers and educators including lecturers of public universities and secondary school students nationwide (Teoh & Fong, 2005). Unfortunately to date full implementation of the project is still pending. Teoh and Fong (2005) cautioned that teacher enthusiasm and willingness to use the tool is an issue to be addressed. Subsequently, Kasmawati (2006) made known that two major reasons given by the some 151 Malaysian teachers who had undergone GSP training courses but are still reluctant to use the technology were (a) lack of time to prepare a GSP lesson and (b) lack of skill and confidence to use GSP to teach mathematics in class. It is undeniable that teachers will need to internalize the skills in solving mathematical tasks with the use of technological tools in order to capitalize the power of technology. A viable way to impart this new knowledge to the teachers is through the *Lesson Study* (LS). LS is a form of teacher professional development that aims to enhance teachers' pedagogical knowledge and skills through peer review, critique and collaboration among teachers (Shimahara, 1998). It is managed by small groups of teachers (four or five teachers) who meet regularly at a stipulated time to plan, implement, evaluate, and revise lesson plans collaboratively. Several research studies (Fernandez & Yoshida, 2004; Lewis, 2000; Lewis & Tsuchida, 1998; Lim, White & Chiew, 2005; Shimahara, 1998; Stigler & Hiebert, 1997, 1999; Yoshida, 1999) have shown that LS improves teachers' learning and supports teachers to grow professionally.

Many research studies have focused on the use of GSP in improving students' geometrical understanding (e.g. Choi-Koh & Sang Sook, 2002; McClintock, Jiang & July, 2002; Ng & Teong, 2003); however, research on how to motivate in-service teachers to teach in technology-related environment is few. This study was conducted with the purpose to examine the effect of embracing LS to promote the innovative use of GSP among secondary school mathematics teachers. More specifically, this study aimed to answer several questions: (1) Can LS motivate in-service teachers to equip their knowledge and skills in GSP? (2) What are teachers' view about the use of GSP on students' learning and understanding of 2-D and 3-D geometry? (3) What are students' perceptions about using GSP to learn 2-D and 3-D geometry? and (4) Does students' mathematics achievement improve in a GSP learning environment?

Method

Context and Respondents

Lesson study is a teacher-led professional development and participation from the teacher is on voluntary basis. The study began by approaching dedicated and voluntary mathematics teachers from different schools in Penang and Kedah who consented to be participants. These teachers were then asked to recruit three to five mathematics teachers from their respective schools to form a lesson study group. Upon their consent, permission was sought from their respective school administrators to include them as respondents. Four lesson study groups were formed. This paper discusses the findings based on two of the four lesson study groups.

Group A consists of four mathematics teachers and 24 students (6 males and 18 females). Group B consists of four mathematics teachers and 22 students (10 males and 12 females). Students in both groups were around 16 years old. All the eight teachers except two are classified as beginners in their GSP knowledge and skills. No student had any GSP knowledge or skills prior to the study.

Procedure

The teachings were conducted in two lesson study cycles from July 2007 till May 2008. In the first lesson study cycle, Group A members selected a lesson in Form 4: *Lines and Planes in 3-Dimensions* to teach. Three discussions were held prior to the teaching. The teaching was observed by all members of the group. Immediately after the teaching, a reflection of the teaching lesson was held. Based on the comments and suggestions, the lesson was revised and re-taught to a different class. In the second lesson study cycle, the Group A members collaboratively decided to use GSP to teach *Loci in 2-Dimensions* as a remedial lesson to the Form 3 students. Three lesson study discussion sessions, comprised of planning of lesson plan and hands-on practices with GSP were conducted prior to the teaching. The teachings were conducted in the computer laboratory and the students were allowed to use computers in their group activities. Reflections on the teaching lessons were held immediately after the observed lessons.

Group B members began with a similar lesson *Lines and Planes in 3-Dimensions* in the first lesson study cycle. In the second lesson study cycle, the group members chose the topic *Plan and Elevation* because they felt that this topic often causes much confusion among the students especially in visualizing the real object in its actual perspectives. Group B did not meet as frequently as Group A for group discussion but they managed to conduct a pre and post test during the second study cycle.

In both groups, students were given a survey questionnaire consisting of 36 items adapted from PISA 2003 Student Questionnaire (PISA, 2003) after the first study cycle. The administered questionnaire was intended to examine the students' perception of the topic taught in a GSP learning environment. The three areas covered were: general perception and interest about the topic (10 items, reliability coefficient α = .8977), cognition or knowledge about the topic (14 items, reliability coefficient α = .8559), and perceived classroom atmosphere or classroom setting during the lesson (12 items, reliability coefficient α = .8810). The scoring is in Likert scale ranging from 1 (*strongly disagree*) to 4 (*strongly agree*).

Results and discussions

New Materials and New Approach to the Existing Syllabus

The planning and discussion sessions were indeed fruitful in generating new materials and a new approach in the teaching of the long-standing topics such as *Loci in 2-Dimensions*. The *"animated program"* (see *Figure 1* to *Figure 4*) is an example of the lesson materials used by the teachers to explore loci. This program was mainly prepared by the school Senior Assistant 1 who was also a State GSP trainer based on the LS lesson plan discussed by the teachers.

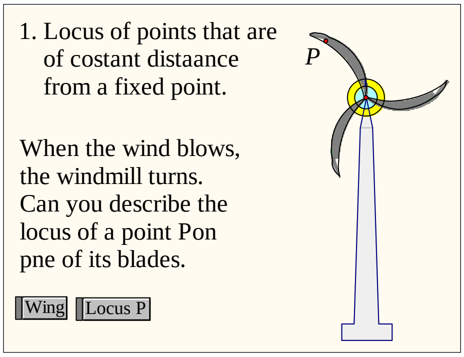

Figure 1

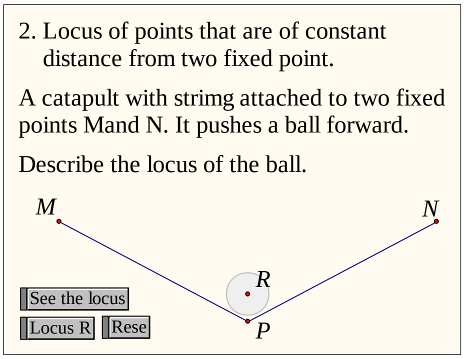

Figure 2

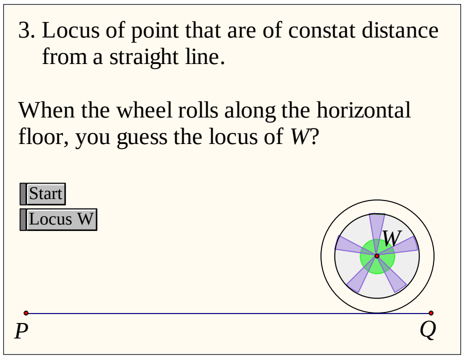

Figure 3

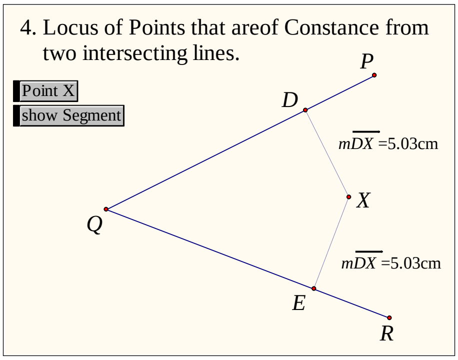

Figure 4

(Source: Lim, C. S., Chew, C. B., Chiew, C. M., & Goh, S. I. (2008). Promoting innovative use of Geometer's Sketchpad (GSP) through Lesson Study collaboration: A case study).

Teachers' s\Skills and Knowledge in GSP after LS Collaboration

The resulting tailor- made GSP lesson has replaced the typical static 2-dimensional representation in the teaching of locus points with the dynamic click on the button. Thereafter the real challenge began when the beginner teachers in the LS collaboration group used their skills and knowledge in GSP to develop questions in the form of worksheets that require students to attempt and verify their answers with GSP (see *Figure 5*). The worksheets were designed based on the Vygotsky's Zone of Proximal Development (1978) and the process of scaffolding. Locus and animation of the points were created to facilitate students making conjectures on the geometrical properties and to confirm their answers with a click on the button. Obviously this designated task could not have materialized without the collaborative effort generated within the teachers' tight teaching schedule.

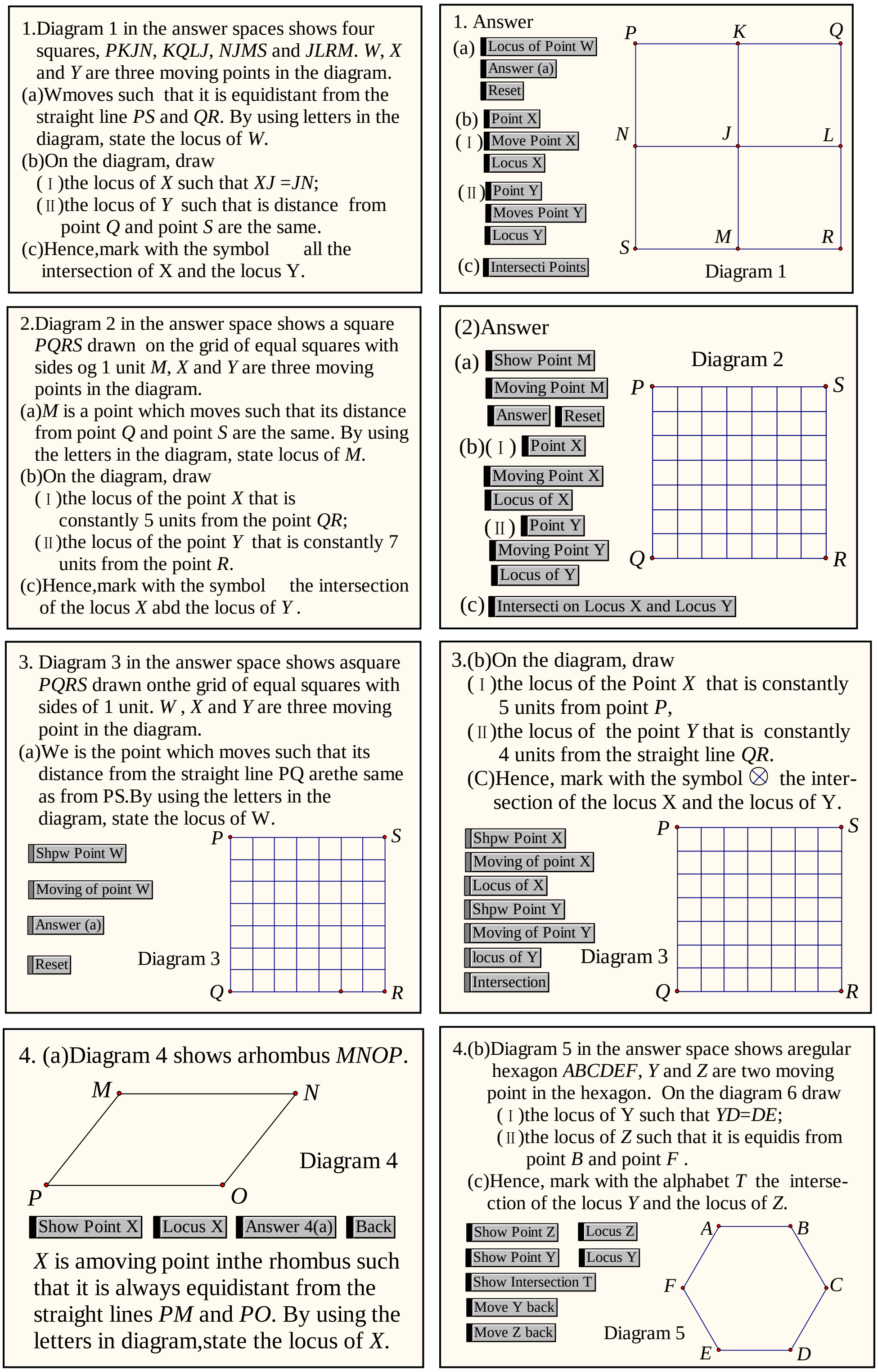

Figure 5. **Examples of student's worksheet.**

(Source: Lim, C. S., Chew, C. B., Chiew, C. M., & Goh, S. I. (2008). Promoting innovative use of Geometer's Sketchpad (GSP) through Lesson Study collaboration: A case study).

The GSP approach adopted by the teacher participants as shown above was novel and innovative in teaching geometry. In the process of the making, teachers' enthusiasm and confidence towards adopting GSP in their routine teaching has undoubtedly improved. Evidences of these teachers' excitement are shown in the interview excerpts outlined below.

Interview Results

Teachers' view about the use of GSP after LS collaboration. Two teachers, KSM and LPC did not use GSP in their teaching due to time constraint and lack of knowledge and skills in GSP. KSM remarked that her tight schedule had hindered her from acquiring new skills and knowledge:

> I feel that I have yet to master this thing [GSP]. If I really want to use it, I have to spend time to really think how I should use it. Maybe I have to create the objects or things and I have to spend time. It seems that I didn't have enough time to do this.
> (KSM, interview, 16/05/08)

However she agreed later that the LS collaboration had given her the opportunity to recall what she had learned before:

> Because during the discussion, we have to make . . . I mean construct the answer for the questions that are used in the teaching. So, at least I can recall back what I had learned. Actually, what I have learned is returned back. You see, I got no time. Sometimes, I have other things. So, this [lesson study] I feel good. At least, I can recall back.
> (KSM, interview, 16/05/08)

LPC said that "*Once in a while, we try. But now, we have no time, too much paper work. We also want to try it but then, as we are getting old, we cannot stand the radiation of the computer."* Nevertheless LPC and four other interviewees shared strong appreciation about lesson study collaboration and were especially encouraged by the peer support from the group members. He added:

> Actually very good. Because if you study alone, it is sometimesa disadvantage. If you face a problem, you will say,

> He! Forget about it and stop there. If you have a friend, you will say, Eh! Come on, come on . . . how to show this? From there, you learn . . . you see.
> (LPC, interview, 16/05/08)

Despite the fact that much effort and time were needed to prepare the lesson, LPC was still keen on the idea of using GSP:

> I think for teaching this topic, if really want them to understand, this one [GSP] is … good . . . to let them the chance hands-on . . . hands-on but teachers need a lot of preparation.
> (LPC, interview, 16/05/08)

Similarly, AZI expressed her opinion on the effectiveness using GSP to teach the selected lesson:

> My teaching now . . . I feel relax in the teaching because we are not restricted to what to be taught. The students have learned it [before]. I like it [teaching] because the students seemed eager to learn in the lesson. Before this, I showed it in front, use the GSP and display it to students. They have not tried it. Now, the students hands-on with it [GSP] and I only use little time to explain. The students tried it, so I feel joy.
> (AZI, interview, 16/05/08)

Students' perception about GSP incorporated lessons. Below are some positive remarks about GSP incorporated lessons made by several Group A students :

> "…more fun …using computer [GSP] can be better." (G1: S1)
> "… more mind-boggling type, not so boring." (G1: S1)
> "…hope to have more computer use. More high tech." (G1: S1)
> "…with computer, we can do faster, easier to understand." (G1: S5)
> "…more flexible." (G1: S4)

There is a clear indication that peer support is important in learning a new task that involves the use of computer:

> Computer can be horrifying. Because when you have problems, with friends you can discuss, you can teach each other whatever you don't understand, it is more convenient. If alone, you don't understand, you have to run to ask others. Together is better, you can discuss.

(G2: S4)

In addition, some positive and encouraging reflections expressed by the Group B students are:

"… learn math better with GSP instead of only with a book." (G2: S18)
"… spend more time on math now than before." (G2: S7)
"I feel confident about trying a new problem on GSP..." (G2: S3)
"…able to interact with my teachers and friends with GSP…" (G2: S18)
"GSP… helps me to learn math by discovering." (G2: S21)

Descriptive and Inferential Statistics Findings

The administered questionnaire to examine the students' perception of the topic taught in a GSP learning environment received scoring ranging from 1 (*strongly disagree*) to 4 (*strongly agree*). Descriptive statistics shows the means all the three areas ($M_{general}$ = 3.60, *SD* = .31; $M_{content}$ = 3.46, *SD* = .40; $M_{classroom}$ = 3.51, *SD* = .33) of student s' perception were above 3 indicating that students perceived positively towards a GSP learning environment. On the general perception of the topic taught with GSP**,** all students (100%) agreed that they liked the GSP class, they still remember the topic content they had learned with GSP and they did not find the topic difficult to study. In addition, 90.5% of the students agreed that they scored high marks in this topic. They agreed strongly to the items such as

Items	% agreed
I look forward to my mathematics class.	100%
I enjoy learning this topic.	100%
I am interested in the things I learned in this topic.	100%
I made real effort in learning this topic because I want to be one of the best.	100%
I am more confident in this topic than others.	100%

On the cognitive aspect, all students agreed that they learned the content well and agreed to the following statements:

Items	% agreed
I make effort to ask questions if I don't understand what he/she is saying.	95.2%
I can imagine/visualize the 3-D object in my head vividly.	95.2%
I can understand his/her teaching without much problem.	85.7%

I have forgotten many of the things that I have learned in the class.	4.8%

It is interesting to note that only 4.8% and 9.5% of the respondents agreed to the negative statements such as "…forgotten many of the things …learned…" and "…confused looking at the objects …on screen…" The positive response to the cognitive items indicates that the GSP intervention was successful in teaching the selected topics. Overall no complaints on technical issues about GSP were received from the respondents. Hence it conforms to Nokelainen's (2006) pedagogical usability criteria that the designed worksheets which complement the GSP should focus on the content of the learning materials rather than problems caused technology.

Pertaining to the classroom environment with GSP, students agreed with the following statements:

Items	% agreed
Students offer spontaneously to help each other to understand the geometry problems in the learning process.	100%
The teacher is in control during the teaching.	100%
Everybody enjoys the lesson very much.	100%
Everybody likes the animation of the object very much and always wants the teacher to show more.	100%
Students are very active most of the time and gave the teacher their cooperation.	100%
There are more discussions in the class than in other subjects.	85.7%

Based on the above perceptions, it can be deduced that the GSP classroom was active and undertaking spontaneous activities such as peer tutoring and small group discussions. The atmosphere was conducive as the teacher was in control of the classroom management and students enjoyed the lessons.

Pre and Post Test Result

A pre test on *Plan and Elevation* was given before the first lesson in Group B. Students were then given 50 minutes to explore using GSP. A similar post test followed immediately after the intervention. It was found that was an improvement in students' achievement. The mean score for the pre test was 13.6 out of 48 and post test recorded 28.4 out of 48 ($M_{pretest}$= 13.6, *SD*

=6.95; $M_{posttest}$ = 28.4, *SD* = 9.14). The total average gain was 14.8 or a 31% increase from the pre test score.

Additionally, the teachers interviewed later mentioned that students would probably work harder and learned better if they were provided with more hands-on environment to explore the software. This reflection indirectly indicates that these beginner GSP teachers were ready to conduct mathematics lessons using more of GSP. When probed further they agreed that LS had helped them to attain a certain level of confidence and motivation to learn more about and how to use the GSP. No complaint of any students' misconduct or lost of classroom control during the course of the study was received from the interviewees. All of them expressed willingness and showed enthusiasm to participate in next study cycle. They were convinced that the best way to sustain LS was to hold group discussion more frequently among mathematics teachers. They also unanimously pointed out that time constraint was the major hindering factor for the LS process. The teachers were pleased with the support from their school authority. The only thing they felt that needed further improvement was the hardware (computer) maintenance.

Interestingly it was observed that teachers in both groups had adapted and set questions that were similar to those in public examination in their GSP worksheets. This attempt came naturally in this examination-oriented generation of teachers. The move was positively received by both teachers and students although it was not explicitly discussed in the lesson study plan. As always, the examination-oriented Malaysian society welcomes heartily any approach that can improve students' achievement in their public examination.

Conclusion

The opinions expressed by the teachers regarding the time constraint were consistent with Beauchamp and Zoller (2002) as well as Shafer's (2008) claims that time factor is the major hindrance for a smooth implementation of LS or new technology. Participant teachers acknowledged that LS managed to coerce them to learn how to use GSP through collegial support despite lack of release time. Through their conversations and commitments in preparing the lessons and attending the small group discussions, it was observed that these teachers' perception and behavior about the adoption of GSP varied from the norm. Evidence to this change was further supported by their call for more GSP hands-on sessions for the benefits of students.

Students and teachers' feedback obtained subsequently confirm that GSP is a tool which facilitates students' learning and teachers' teaching of 2-D and 3-D geometry. Similar to Khairiree's (2004) observation, students worked and learned cooperatively to explore the geometric properties in the presence of GSP. After the GSP intervention, result shows that students scored higher in their paper and pencil test in *Lines and Planes in 3-Dimensions* besides instilling their interest to learn more about it. This outcome is consistent with Almeqdadi (2000) and Dixon's (1997) research findings that GSP enhances students' mathematics performance.

In the future more classroom tests that require GSP knowledge of other topics are called for to validate further the findings. As reported by Lim, Chew, Chiew and Goh (2008), the research team acknowledged the limitation of observing significant changes in teachers and students' knowledge and skills in using GSP and their geometrical understanding comprehensively within a short time. Although the result cannot be generalized, we don't deny the fact that a collaborative group effort such as LS has improved in-service teachers' enthusiasm and willingness to teach with technology, a problem cautioned by Teoh and Foong (2005). Indeed, the result shows that LS has the potential to provide helpful support and sustain the continuous and innovative use of GSP in school mathematics teaching. Teachers in the Malaysian schools will certainly never forget to include the examination-oriented culture in their new teaching task that engages the use of technological tools.

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References

Almeqdadi, F. (2000). The effect of using the Geometer's Sketchpad (GSP) on Jordanian students' understanding of geometrical concepts. *Proceedings of the International Conference on Technology in Mathematics Education* (pp. 163-169). Lebanon.

Beauchamp, A., & Zoller, K. (2002). The opportunity and challenge of lesson study. *CSP Connection, 2*(6), 3.

Chi, K. & Sook, S. (2000). The activities based on van Hiele model using computer as a tool. *Journal of the Korean Society of Mathematical Education Series D: Research in Mathematical Education, 4*(2), 63 - 77.

Dixon, J. K. (1997). Computer use and visualization in students' construction of reflection and rotation concepts. *School Science and Mathematics, 97*, 352-358.

Fernandez, C., & Yoshida, M. (2004). *Lesson study: A Japanese approach to improving mathematics teaching and learning*. Mahwah, NJ: Erlbaum.

Finzer, W., & Jackiw, N. (1998). *Dynamic manipulation of mathematical objects*. Retrieved December 2, 2008, from http://www.keypress.com/sketchpad/talks/s2k/index.htm

Hannafin, R. D., Burruss, J. D., & Little, C. (2001). Learning with dynamic geometry programs: Perspectives of teachers and learners. *The Journal of Educational Research, 94*, 132-144.

Kasmawati Che Osman (2006). *Meninjau penggunaan Geometer Sketch Pad (GSP) di kalangan guru matematik sekolah menengah Pulau Pinang*. Unpublished master's thesis, Universiti Sains Malaysia, Penang, Malaysia.

Khairiree, K. (2004). Exploring geometry with the Geometer's Sketchpad. In Yahaya Abu Hassan et al. (Eds.), *Integrating technology in the mathematical sciences* (pp. 145 -153). Southampton. UK: USM.

Lewis, C., & Tsuchida, I. (1998). A lesson is like a swiftly flowing river: Research lessons and the improvement of Japanese education. *American Educator*, 22(4), 12-17; 50-52.

Lewis, C. (2000, April). *Lesson study: The core of Japanese professional development*. Paper presented at the annual meeting of the American Educational Research Association, New Orleans, LA.

Lim, C. S., Chew, C. B., Chiew, C. M., & Goh, S. I. (2008, October). Promoting innovative use of Geometer's Sketchpad (GSP) through lesson study collaboration: A case study. Paper presented at *Seminar Kebangsaan Pendidikan Sains dan Matematik 2008,* anjuran Persatuan Pendidikan Sain dan Matematik Johor in cooperation with Johor Department of Education and Faculty of Education UTM, Universiti Teknologi Malaysia.

Ng, K. E. D., & Teong, S. K. (2003). The Geometer's Sketchpad for primary geometry: A framework. *Micromath, 19*(3), 5-9.

Nikelainen, P. (2006). An empirical assessment pf pedagogical usability criteria for digital learning material with elementary school students. *Educational Technology & Society, 9*(2), 178-197.

Nurul Hidayah Lucy Bt Abdullah (2005). *The effectiveness of using dynamic geometry software on students' achievement in geometry*. Unpublished master's thesis, University Malaya, Kuala Lumpur, Malaysia.

PISA. (2003). *PISA 2003 student questionnaire. Section E: Learning mathematics.* Retrieved January 10, 2008, from http://pisa2003.acer.edu.au/

Shafer, K. (2008). Learning to teach with technology through an apprenticeship model. *Contemporary Issues in Technology and Teacher Education, 8*(1), 27 -44.

Shimahara, N. K. (1998). The Japanese model of professional development: Teaching as craft. *Teaching and Teacher Education, 14,* 451-462.

Stigler, J. W., & Hiebert, J. (1997). Understanding and improving classroom mathematics instruction: An overview of the TIMSS video study. *Phi Delta Kappan, 79*(1), 14-21.

Stigler, J., & Hiebert, J. (1999). *The teaching gap: Best ideas from the world's teachers for improving education in the classroom*. New York: Free Press.

Teoh, B. T., & Fong, S. F. (2005). The effects of Geometer's Sketchpad and graphic calculator in the Malaysian mathematics classroom. *Malaysian Online Journal of Instructional Technology, 2*(2), 82-96.

Vygotsky, L. (1978). *Mind in society*. Cambridge, MA: Harvard University Press.

Yoshida, M. (1999, April). *Lesson study (Jugyokenkyu) in elementary school mathematics in Japan: A case study*. Paper presented at the American Educational Research Association, Montreal, Canada.

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