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USING GEOMETER'S SKETCHPAD FOR TEACHING AND LEARNING OF GEOMETRY: THE CASE OF EIGHTY PRE-SERVICE TEACHERS

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Abstract

This paper reports on the investigation of pre-service trainee teachers' perception of the use of the Geometer's Sketchpad (GSP) for the teaching and learning of geometry. Findings from the survey design suggested that 80% of trainee teachers perceived GSP as a good teaching and learning tool, indicating that GSP has advantageous features that enhance teaching and learning, and GSP can be used as an alternative mode to traditional methods of teaching. Moreover, a large majority of trainee teachers commented positively on the framework for planning GSP tasks, describing it as a 'helpful' guide to lesson planning.

Introduction

Geometry, the study of geometric shapes and structures, and spatial visualisation, has always been an integral part of any mathematics curriculum. In the last two decades, we have witnessed the emergence of dynamic geometry software, Geometric Supposer (Yerushalmy & Chanzan, 1990), Cabri Géomètre (Laborde & Strässer, 1990), The Geometer's Sketchpad (Jackiw, 1993, 995, 1997), and Geometry Inventor (Brock et al, 1994), gaining prominence in international mathematics classrooms. According to the Curriculum and Evaluation Standards for School Mathematics (NCTM, n.d.), technology has an important role in the teaching and learning of geometry, and tools such as dynamic geometry software have a part to play in helping students develop geometric thinking. For example, a dynamic geometry software, the Geometer's Sketchpad (GSP), enables students to model and have an interactive experience with a large variety of two-dimensional shapes, thereby generating many examples in the course of forming and testing conjectures about geometric relationships. However, little is said about how the nature and design of tasks are developed and implemented to enhance this learning experience. In addition, in Singapore, the Ministry of Education's (MOE) vision of Thinking Schools Learning Nation (MOE, n.d.) saw an active promotion of IT-infused lessons in the teaching and learning of geometry using GSP. Since 1997, numerous in-service courses conducted by MOE (ETD, 1999, 2001, 2003) and sharing sessions at the Teachers' Network (Teh, 1998) have been a contributory factor in maintaining teachers' interest in the software. However, many local and international research studies have often focused on teaching ideas and the potential of GSP in the teaching and learning of geometrical proofs and relationships. There appeared to be an absence of local research into the use of GSP in teacher education and their impact. This study focuses on providing pre-service trainee teachers a GSP mathematical pedagogy training using a framework, which the authors developed (Ng & Teong, 2003), and then examining their perception of the use of GSP for the teaching and learning of geometry at the primary and secondary levels.

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Research Design

The study adopted a survey design to examine pre-service trainee teachers' perception of the use of GSP for the teaching and learning of geometry. Due to constraints of time and accessibility of trainee teachers, seventy-eight trainee teachers, who were in the authors' classes, were involved in the study. Twenty trainee teachers were training to teach lower secondary mathematics while fifty-eight trainee teachers were training to teach primary mathematics. These trainee teachers had diverse mathematical experiences, but all of them had at least undertaken GCE 'O' level mathematics and those who were training to teach lower secondary mathematics had at least undertaken GCE 'A' level mathematics. All trainee teachers consented to participate in the study. It was found that 65% of the trainee teachers did not have experience using GSP in the teaching and learning mathematics before the intervention. In the study, all trainee teachers were exposed to a short intervention programme of approximately six hours comprising of:

1. introduction to software use, levels and types of tasks represented in the framework (Ng & Teong, 2003);
2. free exploration of potential and limitations of software; and
3. design of GSP task for teaching and learning of geometry.

At the end of the intervention, the trainee teachers were asked to complete a survey, items which were adapted from Orton and Orton's (1995) study of a similar nature.

Analysis and Findings

Data from the survey were analysed according to three foci: reactions of trainee teachers to GSP as a teaching tool; GSP as a learning tool; and the conceptual framework for planning GSP activities. The qualitative comments of the trainee teachers will also be discussed.

In deciding if GSP was a good teaching tool, trainee teachers were asked to examine the potential of GSP in enhancing their teaching. Table 1 illustrates trainee teachers' reaction towards GSP as a teaching and learning tool. 19.2% of the trainee teachers felt that GSP was indeed a very good teaching tool while close to 70% of the sample had positive reactions to GSP as a teaching tool (see Table 3). The remaining 9 trainee teachers found GSP to be satisfactory to their expectations.

While there is very little difference in the trainee teachers' rating of GSP as a very good teaching and learning tool, an additional 3.86% of the trainee teachers found GSP to be only a satisfactory and poor learning tool as compared to it being a satisfactory and poor teaching tool (see Table 1).

Table 1: Reactions of trainee teachers to GSP as a teaching and learning tool

Reactions to GSP as a	*Very good*	*Good*	*Satisfactory*	*Poor*	*Very Poor*
Teaching Tool	(15) 19.23%	(54) 69.23%	(9) 11.54%	0	0
Learning Tool	(12) 15.4%	(54) 69.2%	(11) 14.1%	(1) 1.3%	0

$N = 78$

When asked if they would use GSP in their teaching if all facilities of its easy use in school were available, 82.29% of the trainee teachers expressed keen interest in the potential of the software forming part of their teaching repertoire in the future (see Table 2). Reasons justifying trainee teachers' preferences for using GSP in their future lessons included the advantageous features of GSP to help enhance teaching and learning, and the potential of GSP as an alternative mode to traditional methods of teaching.

Table 2: Whether trainees will be using GSP in their teaching

Definitely	Probably	Possibly	Probably not	Definitely not
(19)	(45)	(13)	(1)	0
24.36%	57.69%	16.67%	1.28%	

N = 78

According to the trainee teachers, the dynamic nature of GSP, particularly complemented by its drag mode, could assist in the spatial visualization of concepts, providing a virtual hands-on effect during learning. Indeed, in some occasions, GSP constructions are so 'virtually tactile' (Purdy, 2000, 224) after dragging, that it is probably more effective in conveying geometrical ideas than paper cutouts. As pointed out by some trainee teachers, the many examples generated from the drag mode might well help pupils experience the informal proofs of geometrical theorems and properties, making GSP a good demonstration tool for mathematics lessons. Also mentioned was the potential of GSP as an alternative mode to traditional methods of teaching. It was maintained that GSP added variety to the existing tools/media to teaching, providing an exciting and stimulating way of learning geometry. This could perhaps be attributed to the dynamic nature of software which might promote self-exploration, learning through 'concept discovery' (Stone, 1994, 592) and geometrical thinking.

The only trainee teacher who felt strongly against using GSP in her teaching cited time constraints as a crucial factor withholding teachers from considering using GSP in their lessons. This trainee teacher was concerned with the amount of time needed just to construct geometrically sound GSP templates for pupils. She found the 'draw tool' in MS Word to be more 'user-friendly' for the purpose of drawing shapes and figures and GSP to be 'tedious' and 'time-consuming'.

The opinions of the trainee teachers were also sought in deciding the best features of GSP as a teaching and learning tool. Trainee teachers' opinions and their indicated best features of GSP are recorded in the following table, Table 3.

Table 3: Best feature(s) of GSP as a teaching and learning tool

Best Feature	*As a Teaching Tool*	*As a Learning Tool*
User-friendliness	• simple tool bar buttons	• interactive and immediate visuals provided
Drag mode	• illustrations of geometrical properties done quickly and with a certain degree of accuracy	• useful for showing informal proofs
Measurement & calculation	▪ calculations and measurements done quickly	

Trainee teachers were also asked to suggest very briefly how GSP could be used in their teaching and discussed the potential and limitations of the software for the idea. An extract of some of their ideas are categorically documented, in Table 4, according to individual student input.

Table 4: GSP use in teaching, including its potential and limitations

Topic	*Advantages*	*Limitations*
Angle Properties	• students discover angle properties themselves rather than just remembering what was told.	• not all students can grasp with the basics of construction and a lot of time might be spent on one aspect.
Sum of Angles in a Triangle	• students get to explore and discover the concept for themselves relatively easily	• approach may not work well for students who prefer paper cutting to the computer.
Pythagoras' Theorem	• Proofs	

It was not surprising that trainee teachers' suggestions on how GSP could be used in the lesson closely resembled those topics set for assignments. This could be because of time constraints during GSP intervention sessions resulted in the absence of in-depth and wide scope of GSP explorations. There was a limit to the variety of topics dealt with in the intervention sessions.

A large majority of the comments on the framework for planning GSP tasks were positive, describing it as a 'holistic' and 'helpful' guide to lesson planning as it steered trainees towards a more structured presentation of the lesson by emphasizing on the objectives and degree of pupil-exploration. The framework was conceptualized to guide trainee teachers in planning for a GSP-infused lesson. The four levels postulated alerted teachers in pitching their lesson to the needs of the pupils and the topic. These levels are by no means fixed. It is possible, as some trainee teachers had pointed out, that teachers tend to plan their lessons involving a combination of the different levels of GSP usage because most classes are mixed-ability.

Implications of Study

At least 80% of the trainee teachers involved in this study seemed to perceive GSP as a good teaching and learning tool. This was consistent with the conclusion drawn from that of trainee teachers being receptive to using GSP in their future teaching.

The dynamic nature of GSP, its powerful almost all encompassing drag mode, was one of the main factors capturing trainee teachers' interest in the software. Trainee teachers were also impressed with the accuracy and speed of measurement and calculations done on GSP which in some ways has the potential to aid informal deductions of geometrical properties. To many trainee teachers, GSP presents a whole new experience of learning and teaching geometry, one involving varying degrees of explorations aimed at discovering interesting geometrical phenomena.

Findings of the study may have implications on the teacher-preparation course for GSP. For instance, the framework could be introduced with more explanations and examples on what is meant to teach, consolidate, do informal proofs and solve problems using GSP, thereby providing trainee teachers with a more comprehensive and thorough look on the applications of GSP for various topics in the primary and secondary syllabuses. More can also be done to help trainee teachers differentiate between the purposes and differences in task design when using dynamic geometry software in constructions as compared to word processing tools.

As this study is first of its kind on trainee teachers' perceptions of GSP in local context, a parallel comparison study may be conducted for existing teachers to gain an insight on how GSP is used in Singapore schools as well as collect feedback on the practical uses of the framework.

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