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The Effects of Geometer's Sketchpad and Graphic Calculator in the Malaysian Mathematics Classroom

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Abstract

This study examined the effects of using the Geometer's Sketchpad (GSP) and the graphic calculator (GC) in the learning of the vertex form of quadratic functions among field dependent (FD) and field independent (FI) cognitive style students. The GSP and GCs are two innovative tools introduced in Malaysia in the teaching and learning of secondary school mathematics. This study found that the students performed as well when using the GSP or the GC in the learning of quadratic functions by way of the visualisation of graphs. The FI students outperformed the FD students in both tools. The implications of this study in using the GSP and GC in the mathematics classroom are discussed.

INTRODUCTION

The Geometer's Sketchpad (GSP) is a computer software system for creating, exploring, and analysing a wide range of mathematics concepts in the field of algebra, geometry, trigonometry, calculus, and other areas (Geometer's Sketchpad, Reference Manual, 2001). Recently the Malaysian Ministry of Education (MMOE) made the unprecedented but bold and wise decision of subscribing to the license of this software in 2004. The license was not only meant for the quarter of a million teachers and educators including lecturers of public universities but also for the almost 5 million students who are under the direct authority of the MMOE nationwide (Ministry of Education Malaysia, 2001). In the case of graphic calculators (GCs), the Ministry of Education has started distributing them to several hundred secondary schools throughout the country since 2002 (Norjoharuddeen, 2004).

In the teaching of algebraic functions, many teachers still rely on the chalk and talk approach or more commonly known as the traditional method. Visualisation is minimal if at all. Drawing of graphs if done are sketches which are static, not according to scale and very too often distorted. The use of visualisation tools like the GSP and GC in this research will present an alternative to overcome these instructional inadequacies.

In the learning of algebraic functions, students usually find graphing tedious and time consuming (Podlesni, 1999) and they only manage to learn limited number of graphs in the limited time available in class. Little time is spared for application and problem solving, some of which problems are impossible with paper and pencil alone (Harvey et al., 1995). The availability of the GSP and GC will make these sketches instantaneous thus saving precious time for the answering of after-graphing questions, the comprehension of concepts, problem solving and application. This however does not in any way undermine the importance of skills in manual graphing which are essential in the examination. A yearly report issued by the Board of Examination, MMOE indicates that students taking SPM additional mathematics failed to possess sufficient skills and knowledge to answer questions on completing the square method, and thus the vertex form in quadratic functions (Malaysian Ministry of Education, 2002).

Current development in the field of teaching and learning of mathematics in Malaysia compels teachers to choose the instructionally better alternative tools in the teaching of mathematics, generally and in quadratic functions, specifically. The GSP and GC are such current available tools. All secondary schools technically should have been supplied with the GSP and more schools will be equipped, either through their own initiative or otherwise, with the GC. This study intends to help them make that choice.

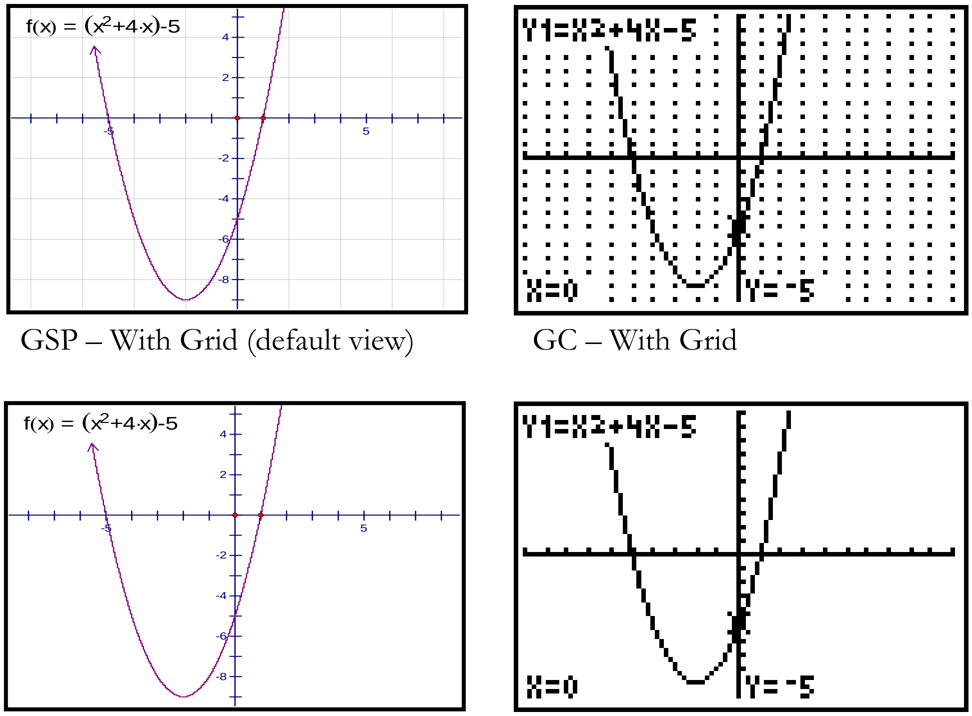
Graphs have always been a problem with certain students. In psychology these students have been found to possess, among other traits, certain cognitve styles which put these students at a disadvantage in viewing and thus in understanding graphs. Graphs are embedded figures within the axes and grids. Witkin et al., (1977) found that FD students, in contrast to FI ones, show varying difficulties in such embedded figures. The GSP and GC, while providing some excellent tools in the visualisations, also face the challenge of providing support to these students. Various visual mode options are available both in the GSP and GC. One of them is the option of showing or hiding the grid. In default, the GC hides the grid with *GridOff* mode but in contrast GSP shows grid as default view. Figure 1 shows the various visual modes in the GSP and GC. In this study, the researcher has maintained the default views in both tools when introducing the intervention. This decision made was based on the rationale that the developers of these tools must have very good and valid reasons to make their respective views default. This study then hopes to find the better tool in helping the normally disadvantaged students. Visuals in Figure 1 are not shown according to scale.

The theoretical framework supporting this study is based upon the information processing theory (Gagné, 1984) and the dual coding theory (Paivio, 1986). All the 5 hypotheses postulated and tested were null hypotheses because of the lack of literature on studies done in comparing the use of the GSP and GC (Gay & Airasian, 2003).

LITERATURE REVIEW

Geometer's Sketchpad in Learning

The use of dynamic geometry software has been explicitly suggested in the curriculum specifications for secondary school mathematics (Ministry of Education Malaysia, 2001). The GSP is one such software. In GSP, Almeqdadi (2000) found a significant difference between the means of the students' scores on the posttest of those using GSP and those using only the book in the learning of some geometrical concepts. Students using the GSP performed significantly better than those using books only. McClintock et al., (2002) did a qualitative study on students' development of 3D visualisation in the Geometer's Sketchpad environment. The students were taught geometric solids among other concepts for 10 to 20 weeks using GSP. They found that the GSP and the associated activities were effective in helping the students develop 3D visualisation and achieve conceptual understanding of geometry content. The immediate feedback provided by the dynamic environment allowed the students to verify or change their conjectures. They found that the students have progressed significantly in terms of their geometric thought.



GSP – With Grid (default view) GC – With Grid

GSP – Without Grid GC – Without Grid (default view)

Figure 1: Different Visual Displays of GSP and GC

Garofalo & Bell (2004) took a new look at using GSP in teaching area. His activity sketches started from elementary to college level and showed how GSP sketches could be extended and expanded to enrich the teaching and learning of mathematics at different grade levels in area. Purdy (2000) on the other hand used GSP to visualise maximum-volume problems. He found problems like the maximum-volume that were once reserved for higher courses now has surfaced earlier in high school as interesting and practical explorations that could be tackled with the use of GSP. On top of that, as a result of their explorations he found that his students have been led to a deeper understanding of the problem and its solutions. Quinn (1997) found that GSP is an invaluable aid in teaching graph theory in her discrete-mathematics class. She found that GSP not only supply a tool to create sketches that were tedious to draw and redraw or were hard to visualise, it also gave her students insight to proof or disprove certain graphs based on the theory.

Embse (2001) suggested making dynamic visualisations a part of every calculus teacher's explanations. He found that teachers typically presented static pictures and graphs to explain calculus concepts. He used GSP to construct dynamic graphs of functions to geometrically present successfully the fundamental ideas of calculus. Scher (2003) used a new approach to solve a classic problem by way of dynamic visualisation and offering proof using the GSP. By developing a non-algebraic approach and by making interactive constructions and setting static sketches into motion he was not only able to solve the pirate treasure problem but was able to hit upon the important elements of proof with GSP. Kelly et al., (2002) discussed how they have attempted to help students gain a working understanding of perspective by using GSP. The students explore drawing isometric views guided by a skilful teacher and found that the students were prepared to encounter more formal study of perspective. Teacher coaching was found to be a very important factor in students gaining the understanding of perspective.

There is general consensus (Battista, 1999; Greeno et al., 1996) that for optimal learning of mathematics, ideas must be constructed by the learner. NCTM Standards (2000) suggest that students be engaged in scientific inquiry and in problem solving. In the current study, assistance was extended to the students in the use of their respective tools but no scaffolding to the learning topic was provided. However the students were allowed to collaborate in line with the social constructivist theory of learning. And the modules developed were based on scientific enquiry-discovery approach suggested above and as proposed in the integrated curriculum for secondary schools for mathematics (Ministry of Education Malaysia, 2001).

Graphic Calculator in Learning

The use of GCs has also been explicitly proposed in the curriculum specifications for secondary school mathematics (Ministry of Education Malaysia, 2001). The Texas Instrument TI-83 Plus is one such calculator. Noraini et al., (2003) compared the effects of students' achievement in the learning of algebraic functions by the use of TI-83 GC. The students were exposed to the working of the GC for five weeks. From the pretest-posttest results she found that the students using the GC showed significant improvement compared to students using traditional instruction. Weiss (2004) showed that the graphing of trigonometric identities on a TI-83 GC. She showed when modifications were done to accommodate the specific resolution of the display screen, functions could be drawn to exhibit similar behavior on most GCs compared to the computer graphics screens. Changing the resolution requires operating the WINDOW function key on the GC. This WINDOW function has also been incorporated in the modules in the current study to enable better viewing of the quadratic graphs. Embse & Engebretsen (1996) found setting a friendly window on GC depended on two factors: a proportional distance between X_{min} and X_{max} or between Y_{min} and X_{min}; and an appropriate starting value for X_{min} and Y_{min}.

Dyke (2003) found that students resort to complicated algebraic expressions rather than read information from graphs and thus ignoring these important graphs. In order to place greater emphasis on graphs, she suggested introducing concept of function by the use of graphs through the GC. Knuth (2000) reported in his study that students did not recognise that a graph and an equation are two representations for the same sets of points. On the contrary, Edwards (2002) believed that traditional step-by-step manipulation with pencil and paper strengthened students' understanding of basic algebraic concepts in a way that most calculator-based methods did not. The existence of GCs and other technology-based tools did not eliminate the importance of symbolic manipulation in algebra classrooms.

Cavanagh & Mitchelmore (2000) identified in their study three misconceptions the students did when interpreting linear and quadratic graphs on a GC screen: they have a tendency to accept the graphic image uncritically, without attempting to relate it to other symbolic or numerical information; a poor understanding of the concept of scale; and an inadequate grasp of accuracy and approximation. These misconceptions brought some important implications to teaching. They suggested that scales, including asymmetrical scales, and decimal approximations be given more curricular emphasis and attention. They cautioned that it was often claimed that visual images provided by GC could strengthen student's conceptual understanding. They found visual images could also be misleading. Students who were not strong visualisers could find such graphs problematic. They further suggested that these misconceptions may also lessen with greater exposure to GC. This is supported by Ruthven (1990) who found that regular access to technology could have positive influence on linking different representations of functions.

Whitehead (1929) noted that when students were asked to solve problems relating to concepts and procedures they already mastered, they often failed. Their knowledge remained inert. Sherwood et al., (1987) provided support in their study regarding the same inert knowledge when teaching logarithms. The vast majority of the students could not apply what they have learnt. In this respect, Lopez (2001) found that the use of GC helped the students make connections between problem solving exercises that they did to the mathematical concepts that they already knew.

Comparing the Geometer's Sketchpad and Graphic Calculator in Learning
Up to date, the only local study concernng GSP and GC was conducted by Ling in 2004. In her study, Ling (2004) compared three groups: two technology groups using respectively the GSP and GC, and the control group using traditional instruction in the learning of conics. She combined the technology groups with teaching. Some students had their own GCs which showed that GCs were quite as readily available as scientific calculators in Malaysia. While others who had not their own GCs were allowed to bring the GCs provided to them home and use them as much as they would like and needed to. Cooperative approach among students in groups of four was employed for two months before the actual intervention using conics. The two technology groups did not score significantly better than the control group. Overall, she found that all the groups showed significant increases on the posttest scores.

Field Dependence-Field Independence (FDFI) and Learning
Witkin et al., (1977) introduced the term "cognitive style" to describe the concept that individuals consistently exhibit stylistic preferences for the ways in which they organise stimuli and construct meanings for themselves out of their experiences (Ayersman & Minden, 1995). Cognitive styles include variables within a single dichotomy such as global-holistic vs. focused-detailed, right-brained vs. left-brained and field-dependent vs. field-independent. Among the above variables, field dependence and field independence, which reflect one's mode of perceiving, remembering and thinking, has emerged as one of the most widely studied cognitive styles with the broadest application to problems of education (Worthley, 1987).

Many studies have reported important implications of FDFI coginitve styles in education (Witkin et al., 1977; Canelos et al., 1980; Maznah & Ng, 1985). According to Witkin et al.'s (1977) definition, field independence is the extent to which a person perceives part of a field as discrete from the surrounding field rather than as a whole, rather than embedded in the field or the extent to which the person perceives analytically. Witkin & Goodenough (1981) found that individuals who were classified as field independence were able to perceive context in a field and is able to view it as discrete from the surrounding field rather than as a whole. On the other hand, FD individuals needed to be assisted through the field and were influenced by the field factor, the surrounding visual complexity and tend to rely on external cues to make decisions (Adams & McLeod, 1979).
Studies that found characteristics of the FDFI students as cited by Musser (2005) are given below:

- FDs are dominated by salient cues in concept-learning tasks, use a passive approach to learning, are more affected by negative reinforcement, and are better at incidental learning of social information (Goodenough, 1976).

- FDs had more difficulty in abstracting relevant information from instruction supporting more difficult learning tasks (Canelos et al., 1980).
- FD students learnt mathematics better from a FD instructor than from a FI teacher (Packer & Bain, 1978).
- FI students learnt the most in math lessons when given minimum guidance & maximum opportunity for exploration and discovery, whereas field dependents profited most from maximum guidance (Adams & McLeod, 1979).
- FI students were correlated with higher mathematics achievement especially for concepts and application (Vaidya & Chansky, 1980).
- FI students learnt more from an individualised, self-paced course than FDs (Wilborn, 1981).
- When collaborative pairs of learners consisted of two FIs, they performed much better than two FDs (Frank & Davis, 1982).
- Text passages with headings improved scores for FD students, whereas FI students scored better in passages without headings (Thompson & Knox, 1987).

RESEARCH METHODOLOGY

This research used the quasi-experiment, non-equivalent control group pretest-posttest 2 x 2 factorial design. The dependent variable for this study was the posttest score of the students, the independent variables were the GSP and the GC and the moderators were the FDFI cognitive style.The research sample consisted of four homogeneous form 4 classes, aged between 15 and 16 years old. A total of 105 students involved in this study but only 90 of them managed to complete it. There were 43 students using the GSP and 47 the GC. Of these 50 were FD students and 40 were FI students.

Four modules were developed to enable the students learn about the quadratic functions. Two were familiarisation modules and two treatment modules. The students involved were initially surveyed for their familiarity with the GSP and GC. None of them in the treatment group were found to have used either of the tools. The familiarisation modules were developed to enable the students to be familiar with their respective tools. The familiarisation modules introduced the various features in the tools necessary to explore effectively the quadratic functions. The familiarisation modules contain quadratic functions in the standard form whereas the treatment modules contain quadratic functions in the vertex form. One module was for the GSP group and one for the GC group. Both modules employed the exploratory-discovery approach in the learning of quadratic functions.

Instruments used were the survey form on research problem areas, pretest/posttest and the Group Embedded Figures Test (GEFT). The pretest and posttest consisted of 25 multiple-choice questions with four options each and were carried out using paper and pencil for 40 minutes. The FDFI cognitive style students were determined by administering the standardised GEFT instrument developed by Witkin et al., (1971). The pretest and GEFT test were administered two weeks before treatment. The students were then separately exposed to the tools for 40 minutes each using the familiarisation modules before the actual intervention using the treatment modules the very next day. The posttest was administered ten minutes after the treatment.

RESULTS

The data analysis in this study involved the use of descriptive and inferential statistics by employing the SPSS software. TheANOVA was used as the inferential statistic to investigate if there were any significant differences in the scores between the groups. The pretest scores were used to compute for initial differences. The posttest scores were used as the dependent variable for testing the 5 null hypotheses. The significance level of the statistic test was set at $p < 0.05$.

Descriptive Statistics

GEFT Scores for FDFI Classification

Table 1 shows the mean score of the 105 students for the GEFT test to be 6.7810. Those students with scores of 6 and below were classified as FD, whereas those with scores of 7 and above were classified as FIs. There was a total of 51 FD and 54 FI students. The student GEFT scores were continuous from 0 – 18. The prefect score was 18.

Table 1: GEFT scores - Sample means and standard deviations by FDFI groups

FDFI	N	Minimum	Maximum	Mean	Std. Deviation
FD	51	.00	6.00	3.2353	1.9554
FI	54	7.00	18.00	10.1296	2.9527
Total	105	.00	18.00	6.7810	4.2742

Posttest Scores of FDFI Students using the GSP and GC

Table 2 above shows a summary of the mean posttest scores of FD and FI students using the GSP and GC in the learning of quadratic functions. FD and FI students using the GSP respectively managed a mean posttest score of 11.5909 (SD = 2.6665) and 14.6190 (SD = 4.2128).

Table 2: Mean posttest scores and standard deviations of FD-FI students in the GSP & GC groups

	FDFI	N	Mean	Std. Deviation
GSP	FD	22	11.5909	2.6665
	FI	21	14.6190	4.2128
	Total	43	13.0698	3.7884
GC	FD	18	11.6111	2.7038
	FI	29	15.0690	4.6208
	Total	47	13.7447	4.3111
TOTAL	FD	40	11.6000	2.6487
	FI	50	14.8800	4.4154
	Total	90	13.4222	4.0613

In comparison FD and FI students using the GC respectively managed a mean posttest score of 11.6111 (SD = 2.7038) and 15.0690 (SD = 4.6208). The maximum posttest score possible was 25.

Inferential Statistics

Testing for Initial Significant Differences in Mean Pretest Scores between Students in the GSP and GC Groups, and between Students in the FD and FI Groups. The ANOVA analysis results yielded $p = 0.656$ and $p = 0.090$ repectively for the GSP and GC groups, and in the FD and FI groups.

These values show that the GSP and GC groups and the FD and FI groups were all homogeneous on the pretest on a significant level of 0.05.

Hypotheses Testing

$\mathbf{H}_0^1$ **:** There is no significant difference in the mean posttest scores between students using the GSP and the students using the GC in learning quadratic functions.

$$\mu_{GSP} = \mu_{GC}$$

ANOVA analysis results yield p = 0.402. Therefore we fail to reject the null hypothesis, H_0^1. As a result, it is concluded that there is no significant difference in the mean posttest scores between students using the GSP ($\mu = 13.0698$) and the GC ($\mu = 13.7447$) in the learning of quadratic functions.

$\mathbf{H}_0^2$ **:** There is no significant difference in the mean posttest scores between FI students using the GSP and FI students using the GC in learning quadratic functions.

$$\mu_{FI-GSP} = \mu_{FI-GC}$$

ANOVA analysis results yield p = 0.726. Therefore we fail to reject the null hypothesis H_0^2. It is concluded then that there is no significant difference in the mean posttest scores between FI students using the GSP ($\mu = 14.6190$) and the GC ($\mu = 15.0690$) in the learning of quadratic functions.

$\mathbf{H}_0^3$**:** There is no significant difference in the mean posttest scores between FD students using the GSP and FD students using the GC in learning quadratic functions.

$$\mu_{FD-GSP} = \mu_{FD-GC}$$

ANOVA analysis results yield p = 0.663. Therefore we fail to reject the null hypothesis H_0^3. It is then concluded that there is no significant difference in the mean posttest scores between FD students using the GSP ($\mu = 11.5909$) and the GC ($\mu = 11.6111$) in the learning of quadratic functions.

$\mathbf{H}_0^4$**:** There is no significant difference in the mean posttest scores between FI and the FD students using the GSP in learning quadratic functions:

$$\mu_{FI-GSP} = \mu_{FD-GSP}$$

ANOVA analysis results yield p = 0.007. Therefore the null hypothesis H_0^4 is rejected. It is hereby concluded that there is a significant difference in the mean posttest scores between FI and FD students using the GSP. As a result, it is found that FI students ($\mu =$ 14.6190) performed significantly better than FD students ($\mu =$ 11.5909) using the GSP in the learning of quadratic functions.

H_0^5: There is no significant difference in the mean posttest scores between FI and the FD students using the GC in learning quadratic functions:

$$\mu_{FI-GC} = \mu_{FD-GC}$$

ANOVA analysis results yield p = 0.006. Therefore the null hypothesis H_0^5 is rejected. It is concluded that there is a significant difference in the mean posttest scores between FI and FD students using the GC. Therefore it is found that FI students ($\mu =$ 15.0690) performed significantly better than FD students ($\mu =$ 11.6111) using the GC in the learning of quadratic functions.

DISCUSSION

The GSP and GC, and Learning

This finding is in congruence with the finding of the study done on using both the GSP and GC (Ling, 2004). In her study, she found no significant differences between the use of both technology-based tools in the learning of conics. The current study had also not found any significant differences between the use of both tools but in the learning of quadratic functions. In her study, she found that the GSP and GC did not adversely affect the learning of mathematics either. In the current study, it was also found that the GSP and GC had not adversely affected the learning of mathematics. The GSP and the GC both were found to have enhanced students' learning since there were improvements in the students' achievement scores in both the studies.

Although many studies had found positive evidences in supporting the use of GSP and GC in learning, some studies however found that their uses had not brought some desired results in certain areas. Edwards (2002) found that the students who had used the computer-algebra system and the GCs showed undesired proficiency in symbolic manipulation although they had a better knowledge and understanding of algebraic functions. He found that despite the apparent efficiency of calculator-based methods, traditional step-by-step solution strategies continued to play an important role in the classes the study. Some studies even found gender bias in the effectiveness of using these tools.

Ling (2004) found that the use of the GSP and the GC themselves did not fare better than the control or traditional group used in her study. As a matter of fact, the mean posttest score of 21.28 (SD=4.608) of the control was even slightly higher than the mean scores obtained by the two groups although not significantly. Students using the GSP scored 20.00 (SD=7.101) and GC scored 19.61 (SD=6.350). If this was so, then why use these tools in the first place? If traditional methods could achieve what technology could as well if not slightly better in this case, why bother? Technology needs money and lots of other resources to acquire, use and maintain. The GSP was quoted online (Keypress.com, 2005) at US999.95 (RM3799.81) for a 50-user school license and the GC was priced in 2003 at RM7000 for 30 reconditioned units together with some accessories. In spite of this, we strongly believe these innovative tools like the GSP and the GC are here to stay. The number of researches done on using GSP and GC in learning that found positive results are many, probably more than those with negative or neutral findings (Almeqdadi, 2000; Noraini, 2004; Oh, 2002; Smith & Shotsberger, 1997).

Field Dependence-Field Independence Cognitive Style and Learning

In this study there was found to be no significant difference in the mean posttest scores among FI students using the GSP and the GC. There was also found no significant difference in the mean posttest scores between FD students using the GSP and the GC in the learning of quadratic functions. However, there was found to be a significant difference in the mean posttest scores between FI and FD students using the GSP. And also there was found a significant difference in the mean posttest scores between FI and FD students using the GC. This means that the FI students performed significantly better than the FD students in quadratic functions for both tools. The findings could be due to the reason that graphs are embedded figures within the axes and grid. According to Witkin & Goodenough (1981) FD students experience varying degree of difficulties in perceiving embedded figures like graphs. The findings of the current study are supported by Fong (2000); Vaidya & Chansky (1980) and Adams & McLeod (1979).

Many studies have consistently showed the capacity of FIs as compared to the FDs. An FI person tends to approach things more analytically (Witkin et al., 1977) thus are better in learning the current treatment module presented using the exploratory approach than FD students. Generally, FI students are better achievers in mathematics across grades (Vaidya & Chansky, 1980). FI learners have been found to be more successful in isolating target information from a complex whole, like the grid and axes in the Cartesian coordinates, and can process information more accurately on visual search tasks, analyse ideas into their constituent parts, and has the ability to reorganise ideas into new structures. On the contrary, FD learners are less analytic and more global. They tend to see things as a whole. They see the forest rather than the trees. They find difficulty in dissecting fields into their components. In graphs, they probably find great difficulties in separating the curves from the axes and grid.

On this similar note, we should have found differences in the performances between GSP and GC groups. Let's recall that during the treatment both the GSP and the GC had their default view settings for graph display. The GSP displayed the grid while the GC hid the grid. Displaying the grid supposedly made the GSP display more complicated than the GC display. But as it turned out they did not make much of a difference. One reason that could be given to explain this would be that the GSP display uses a computer monitor (15 in.) which is much bigger than the GC display. Although with grid, GSP students especially the FDs might have compensated the more complicated displays with the bigger size and probably the colors of the display in the GSP. As comparison, the GC group (13.7447, SD=4.3111) performed only very slightly better than the GSP group (13.0698, SD=3.7884) in this study even though the GC displayed the graphs without grid.

IMPLICATION AND CONCLUSION

This study showed that the GSP and the GC contributed just as well to the study of quadratic functions. No one tool was superior to the other. Teachers have been spared the decision of choosing which tool is better when they intend to teach quadratic functions. But this finding does not relieve the teachers from using the tools. Mathematics teachers are encouraged to continue using the tools, and to start if they have not. So many researches have found visualisations to promote learning and enhance understanding. Almeqdadi (2000), Embse (2001), Garofalo & Bell (2004), McClintock et al., (2002) and Quinn (1997) have all found GSP to be effective in learning by way of visualisation in the various areas in mathematics. Alexander (1993) and Ruthven (1990) have all found that the use of GCs was beneficial in terms of students' level of understanding and posttest in algebra and calculus. Appropriate visualisations are to be advocated and promoted.

Cost is usually the determining factor in acquiring new teaching and learning aids in school. But we could not say that schools which have one tool need not make further arrangement to acquire the other because of the finding that GSP or GC worked just as well in quadratic functions. This is because each tool has its unique areas of capabilities. The GSP is able to handle geometry, transformations and iteration exceptionally well which the GC could not. On the other hand, the GC (TI-83 plus model) is able to handle statistics, including inferential statistics and matices remarkably well which the GSP could not.

For the GC, the cost of purchasing these tool is undoubtedly high. Some schools have the financial resources to purchase or the fortune to be presented the calculators. But what about the majority of the other schools? Most schools are limited in their budget. For more effective learning, one or two sets in a classroom would not suffice because they are meant for hands-on exploration instead of demonstration. Although the calculators are expensive, one very positive point about GCs is their mobility. Their usage could be in the classroom itself or even during field work. Our recommendation is for as many schools as possible to acquire these innovative tools. The scientific calculator found its place in the mathematics education 25 years ago.

But as for the GSP, that has been taken care of in Malaysia by the purchase of the software license by the Ministry of Education. The license was for nationwide use. Although the license did not allow upgrades to newer versions, the 4.5M version does provide adequate support in mathematics learning. We believe one critical issue in the use of GSP and GC or any new technology based teaching aid for that matter, is the issue of teacher enthusiasm and willingness in their usage. Milou (1999) aptly mentioned in his survey that the successful integration of the GC (& GSP) into the mathematics classroom could not have taken place without the aid of enthusiastic teachers. Teacher perceptions of the GC (& GSP) and its use in the classroom are paramount. Teachers serve as the vital bridge linking these tools to the students. The finding of this study showed that the GSP and GC did not provide effective support to FD students in learning quadratic functions. More research need to be done on FDFI students in the usage of these learning tools. Various effective pedagogical strategies coupled with the usage of these tools could very well be an area to look into to help the FD students.

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