Asia Pacific Journal of Educators and Education, Vol. 27, 105–117, 2012

ASSESSING PRE-SERVICE SECONDARY MATHEMATICS TEACHERS' ATTITUDE TOWARDS GEOMETER'S SKETCHPAD

Chew Cheng Meng
School of Educational Studies
Universiti Sains Malaysia, 11800 USM Pulau Pinang
cmchew@usm.my

Abstract: The purpose of this study was to assess pre-service secondary mathematics teachers' attitude towards Geometer's Sketchpad (GSP) following an introductory GSP workshop. GSP is a dynamic geometry software program used for constructing and investigating mathematical objects. It is a dynamic tool for construction, demonstration and exploration of mathematical objects, adding a powerful dimension to the study of geometry and many other areas of mathematics. A total of 107 pre-service secondary mathematics teachers who attended a mathematics teaching methods course in a local public university participated in the GSP workshop. None of the participants had any prior experience using GSP. Analysis of their responses to the "Geometer's Sketchpad Attitude Scales" indicated that the pre-service secondary mathematics teachers showed a positive attitude towards GSP is more appropriate because the "Geometer's Sketchpad Attitude Scales" was used to access the participants' attitude towards GSP. The results also indicated that there was no significant difference between male and female pre-service secondary mathematics teachers in their overall attitude towards GSP is more appropriate because the "Geometer's Sketchpad Attitude Scales" was used to access the participants' attitude towards GSP. Implications of the study for conducting GSP workshops in mathematics teaching methods courses are discussed.

Keywords: pre-service secondary mathematics teachers, Geometer's Sketchpad (GSP), attitude towards GSP, introductory GSP workshop, regular polygons

Abstrak: Kajian ini bertujuan menilai sikap guru-guru matematik sekolah menengah pra perkhidmatan terhadap *Geometer's Sketchpad* (GSP) selepas satu bengkel pengenalan GSP. GSP merupakan satu program perisian geometri dinamik yang digunakan untuk membina dan menyiasat objek-objek Matematik. Ia adalah satu alat dinamik bagi pembinaan, demonstrasi dan eksplorasi yang menambahkan satu dimensi yang kuat kepada pengajian geometri serta banyak bidang Matematik yang lain. Sejumlah 107 orang guru Matematik sekolah menengah pra perkhidmatan yang mengikuti satu kursus kaedah mengajar Matematik di sebuah universiti awam tempatan mengambil bahagian dalam bengkel GSP tersebut. Semua peserta tidak mempunyai pengalaman menggunakan GSP sebelum bengkel tersebut. Analisis respons mereka kepada "Skala Sikap *Geometer's Sketchpad*" menunjukkan bahawa guru-guru Matematik sekolah menengah pra perkhidmatan tersebut mempunyai sikap positif terhadap GSP. Dapatan kajian juga menunjukkan bahawa tidak terdapat perbezaan yang signifikan antara guru-guru Matematik sekolah menengah pra perkhidmatan lelaki dan perempuan dalam sikap terhadap GSP secara keseluruhan. Implikasi kajian bagi menjalankan bengkel GSP dalam kursus kaedah mengajar Matematik turut dibincangkan.

Kata kunci: guru-guru Matematik sekolah menengah pra perkhidmatan, *Geometer's Sketchpad (GSP)*, sikap terhadap GSP, bengkel pengenalan GSP, poligon sekata

BACKGROUND OF THE STUDY

The use of GSP in the teaching and study of mathematics, particularly geometry, is advocated by the Ministry of Education (Malaysian Ministry of Education, 2003) because it is a dynamic geometry software program used to construct and investigate mathematical objects. In addition, GSP is a dynamic tool for construction, demonstration and exploration, adding a powerful dimension to the study of geometry and many other areas of mathematics. Further, it "can best foster mathematical inquiry and learning through 'dynamic manipulation' experiments" (Finzer & Jackiw, 1998: 2), which possess three main attributes:

1. Students can directly manipulate mathematical objects represented on the computer screen. For instance, students can point at a vertex of a rectangle and directly drag it from point A to point B (see Figure 1).
2. The mathematical objects remain coherent and whole at all times as they are dragged. Continuing with the rectangle example, as the vertex of the rectangle moves from point A to point B, students can recognise that while the orientation and size of the rectangle change continuously, the resulting figure will always be a rectangle, and its property of "four right angles" remains unchanged.
3. Students feel that they are engaged with the mathematical objects that they are manipulating as they are immersed in the dynamic manipulation environment. Most importantly, they can focus on how to achieve their mathematical goals, such as understanding the properties of rectangle, instead of only focusing on how to use GSP.

Research has shown that GSP is an important tool for enhancing students' learning of plane geometry (Choi, 1996; Choi-Koh, 1999; Driskell, 2004; Elchuck, 1992; Frerking, 1995; Thompson, 2006) and solid geometry (July, 2001; McClintock, Jiang, & July, 2002). Furthermore, teaching geometry using GSP that is "based on experimentation, observation, data recording and conjecturing" (Olive, 2000: 3) encourages "a process of discovery that more closely reflects the way mathematics is invented" (Bennett, 1999: viii). Thus, learning geometry in an instructional environment using GSP should "give students the opportunity to engage in mathematics as mathematicians, not merely as passive recipients of others mathematical knowledge" (Olive, 2000: 3–4).

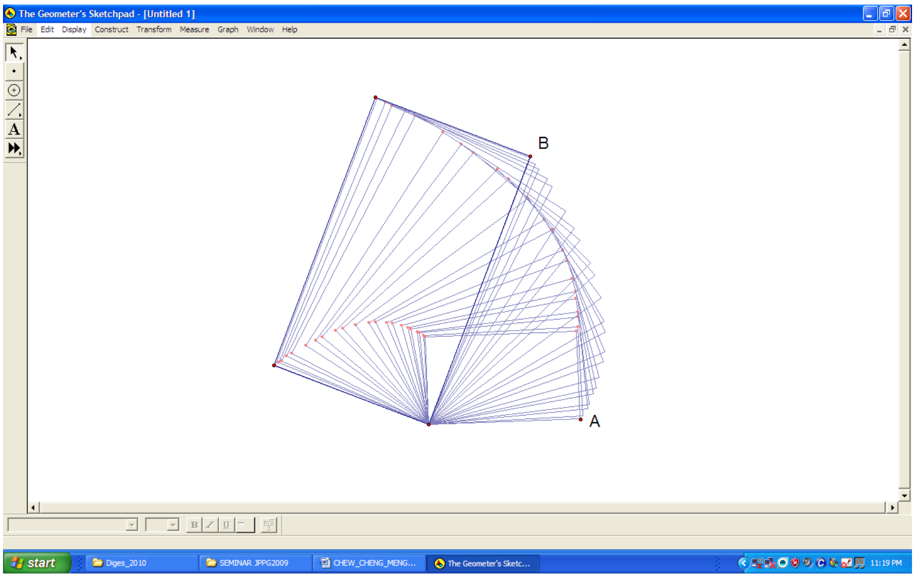

Figure 1. The continuous changes in the orientation and size of a rectangle as its vertex is dragged from point A to point B

However, a brief survey carried out by Kasmawati (2006) on 151 secondary mathematics teachers in the state of Penang revealed that while 26% of the teachers had attended the GSP training courses, only 2% used GSP to teach mathematics in the classroom. Two major reasons given by these teachers were lack of time to prepare a GSP lesson and lack of skills and confidence to use GSP in the classroom. Therefore, there is an urgent need to conduct an introductory GSP workshop in a mathematics teaching methods course to train pre-service secondary mathematics teachers to use the basic tools of GSP for the teaching and study of mathematics, particularly geometry, to promote the use of GSP in the classroom.

PURPOSE OF THE STUDY

The primary purpose of this study was to assess pre-service secondary mathematics teachers' attitude towards GSP after an introductory GSP workshop. The secondary purpose was to determine whether there was a significant difference between male and female pre-service secondary mathematics teachers in their attitude towards GSP. More specifically, this study aimed to address the following research questions:

1. What was the pre-service secondary mathematics teachers' attitude towards GSP after an introductory GSP workshop?

2. Was there a statistically significant difference between male and female pre-service secondary mathematics teachers in their attitude towards GSP?

METHODOLOGY

Participants

The participants of the GSP workshop comprised 107 pre-service secondary mathematics teachers, 70 females and 37 males, who attended a mathematics teaching methods course in a local public university. None of the participants had attended a GSP workshop in the past or had any prior experience using GSP.

Procedure and Instrument

The pre-service secondary mathematics teachers attended a one-hour introductory GSP workshop conducted by the author according to their four tutorial groups. The main objective of the workshop was to enable the participants to use the basic tools of GSP to construct regular polygons, such as an equilateral triangle, square, regular pentagon and regular hexagon (see Figure 2). This skill would be applicable for the teaching and study of geometry in lower secondary schools.

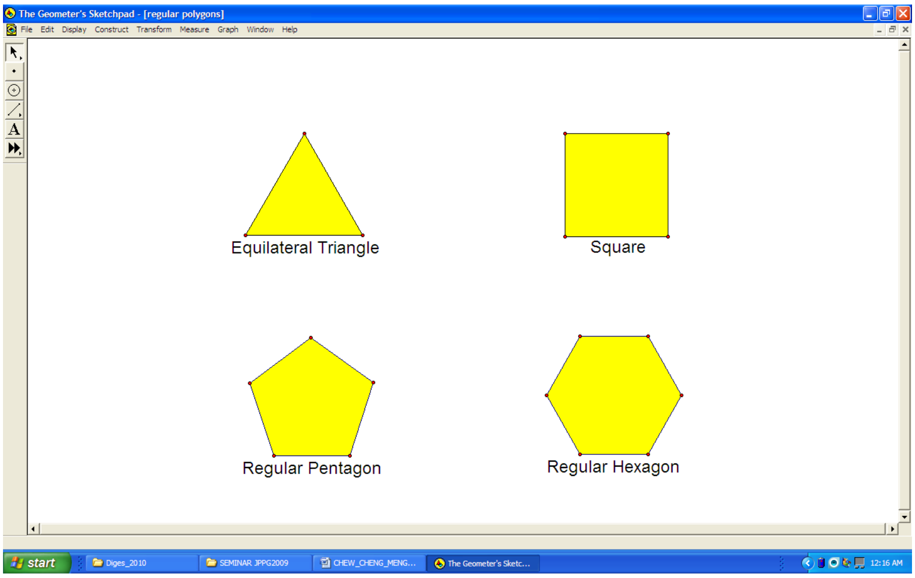

Figure 2. A constructed equilateral triangle, square, regular pentagon, and regular hexagon in GSP

After the workshop, The Geometer's Sketchpad Attitude Scales (GSAS) was administered by the author to all the participants to assess their attitude towards GSP. The GSAS was devised by the author based on the Mathematics Attitude Scales (Meyer & Fennema, 1992: 449–450). The GSAS comprised two sections, namely Section A and Section B. Section A contained items on the pre-service mathematics teachers' background, such as gender and experience of using GSP. Section B contained 18 assessment items of GSP with a 5-point Likert scale (strongly disagree, disagree, neutral, agree and strongly agree). The participants' responses to each item in Section B received weighted values from 1 (strongly disagree) to 5 (strongly agree). One of the items (Item 2) is a negative item, and hence the weighted values for this item were reversed accordingly, i.e., from 5 (strongly disagree) to 1 (strongly agree).

The 18 items were divided into three subscales: Confidence, Autonomy and Liking, with each subscale consisting of six items. The values of the Cronbach's alpha for Confidence, Autonomy, Liking and the overall Attitude towards GSP were .82, .82, .77 and .81, respectively. These indicate a high degree of internal consistency of the items in the three subscales as well as the overall instrument (see Table 1).

Table 1. The subscales and their corresponding item numbers and Cronbach's alpha in the GSAS

Subscale	Item numbers	Cronbach's alpha
Confidence	1, 4, 7, 10, 13, 16	.82
Autonomy	2, 5, 8, 11, 14, 17	.82
Liking	3, 6, 9, 12, 15, 18	.77
Attitude toward GSP		.81

A participant's score on the GSAS was the sum of the weighted values chosen by him/her in the 18 items, with a higher score indicating a more positive attitude towards GSP (Thompson, 1992). The highest possible score for a participant was 90.

RESULTS AND DISCUSSION

The results of this study are discussed in the following sections according to the two main research questions:

Pre-service Mathematics Teachers' Attitude Towards GSP

Table 2 shows the means and standard deviations of the pre-service secondary mathematics teachers' attitude scores for each item in the three subscales of the GSAS.

As seen in Table 2, the means of the pre-service secondary mathematics teachers' attitude scores for all items in the Confidence subscale were above 3.00 except for Item 1 (2.95), suggesting that the participants generally showed confidence in using GSP to construct regular polygons. The mean of the pre-service secondary mathematics teachers' attitude scores for Item 1 was the lowest, indicating that the participants felt that they were not yet proficient using GSP because they had only attended a one-hour introductory GSP workshop. In this short workshop, they only managed to learn the basic tools of GSP for constructing regular polygons and exploring some of the properties of regular polygons, such as measurements of sides and angles. Therefore, the participants felt that they had not yet learned and mastered the more powerful and advanced features of GSP. The highest mean of the pre-service mathematics teachers' attitude scores was 4.00 (Item 10), suggesting that they could learn the basic tools of GSP for constructing regular polygons and exploring some of the properties of regular polygons even after a short introductory GSP workshop.

Similarly, the means of the pre-service secondary mathematics teachers' attitude scores for all items in the Autonomy subscale were above 3.00 with the exception of Item 5 (2.97). This indicates that the participants generally demonstrated autonomy in using GSP to construct regular polygons. The mean of the pre-service secondary mathematics teachers' attitude scores for Item 5 was the lowest, suggesting that the participants felt that working alone in GSP was not enjoyable. The mean attitude score for Item 5 seemed related to the mean attitude score for Item 1; they felt that working alone in GSP was not enjoyable because they were not yet proficient using GSP, having only attended a one-hour introductory GSP workshop. The highest mean of the pre-service mathematics teachers' attitude scores was 3.81 (Item 8), indicating that the pre-service secondary mathematics teachers kept trying even though they encountered difficulties while using GSP to construct of regular polygons.

However, as shown in Table 2, the means of the pre-service secondary mathematics teachers' attitude scores for all items in the Liking subscale were above 3.00, suggesting that the participants generally enjoyed using GSP to construct regular polygons. The mean of the pre-service secondary mathematics teachers' attitude scores for Item 9 was the lowest (3.12), indicating that the participants generally agreed that GSP was their favourite mathematics educational software. The highest mean of the pre-service mathematics teachers' attitude scores was 3.86 (Item 15), suggesting that they thought performing GSP construction of regular polygons was fun even after a short introductory GSP workshop.

Table 2. Means and standard deviations for each item in the three subscales of the GSAS

Subscale	Item	Statement	Mean	Standard deviation
Confidence	1	I am good at GSP.	2.95	.68
	4	I can figure out the steps to the GSP construction of regular polygons.	3.20	.73
	7	I can get the right steps to GSP construction of regular polygons.	3.30	.68
	10	I can learn GSP.	4.00	.57
	13	I am sure about how to perform the GSP construction of regular polygons.	3.37	.68
	16	I feel good about how to perform the GSP construction of regular polygons.	3.69	.59
Autonomy	2	I don't like to be left alone when I am working on GSP.	3.07	.98
	5	I think working alone in GSP is fun.	2.97	.97
	8	I keep trying if I get stuck in GSP construction of regular polygons.	3.81	.66
	11	I like to work alone in GSP.	3.04	.92
	14	I keep trying on hard GSP construction of regular polygons.	3.50	.76
	17	I like to try to solve GSP construction of regular polygons my own way.	3.57	.81
Liking	3	I like GSP.	3.81	.59
	6	I like to do hard GSP construction of regular polygons.	3.31	.87
	9	GSP is my favourite mathematics educational software.	3.12	.81
	12	I enjoy doing GSP construction of regular polygons.	3.80	.61
	15	I think doing GSP construction of regular polygons is fun.	3.86	.61
	18	I think working with GSP construction of regular polygons is fun.	3.79	.67

Source. Adapted from (Meyer & Fennema, 1992: 449–450)

In summary, the participants generally expressed confidence in using GSP to construct regular polygons, as suggested by their responses to Items 1 (*M* = 2.95), 4 (*M* = 3.20), 7 (*M* = 3.30), 10 (*M* = 4.00) and 16 (*M* = 3.69). In addition, the participants' responses to Items 2 (*M* = 3.07), 5 (*M* = 2.97), 8 (*M* = 3.81), 11 (*M* = 3.04), 14 (*M* = 3.50) and 17 (*M* = 3.57) generally indicated that they liked to be autonomous and persistent when working on GSP construction of regular polygons. Moreover, the participants generally expressed their appreciation of GSP and enjoyment while working on GSP construction of regular polygons, as suggested by their responses to Items 3 (*M* = 3.81), 6 (*M* = 3.31), 9 (*M* = 3.12), 12 (*M* = 3.80), 15 (*M* = 3.86) and 18 (*M* = 3.79). Thus, the pre-service secondary mathematics teachers generally showed a positive attitude towards GSP after the introductory GSP workshop.

Difference in Attitude towards GSP in Terms of Gender

Table 3 presents the results of the tests of normality. As seen in Table 3, the Kolmogorov-Smirnov statistic with a Lilliefors significance level for testing normality is significant ($p < .05$) for all the three subscales as well as the overall attitude toward GSP. This means that the attitude scores were not normally distributed in the population and violated the normality assumption of an independent-samples *t* test (Coakes & Steed, 2001; Green & Salkind, 2008). Thus, the non-parametric tests, i.e., the Mann-Whitney *U* tests, were performed to evaluate the null hypotheses that there was no statistically significant difference between the mean attitude score of the male and female pre-service secondary mathematics teachers for the Confidence, Autonomy and Liking subscales as well as the overall attitude towards GSP.

Table 3. Tests of normality

	Kolmogorov-Smirnov[a]		
	Statistic	*df*	Sig.
Confidence	.118	107	.001
Autonomy	.131	107	.000
Liking	.106	107	.005
Attitude toward GSP	.129	107	.000

[a] Lilliefors Significance Correction

Table 4 shows the results of the Mann-Whitney *U* tests. The independent variable was gender while the dependent variable was the attitude scores for the Confidence, Autonomy, and Liking subscales and the overall attitude towards GSP.

Table 4. Mann-Whitney *U* tests for difference in attitude scores in terms of gender

	Male (N = 37)		Female (N = 70)		Z	Sig. (2-tailed)
	Mean rank	Sum of ranks	Mean rank	Sum of ranks		
Confidence	59.05	2185.00	51.33	3593.00	–1.239	.215
Autonomy	62.93	2328.50	49.28	3449.50	–2.187	.029*
Liking	61.61	2279.50	49.98	3498.50	–1.857	.063
Attitude toward GSP	62.03	2295.00	49.76	3483.00	–1.952	.051

* $p < .05$

For the Confidence subscale, the male participants had a mean rank of 59.05 and a sum of ranks of 2185.00, whereas the female participants had a mean rank of 51.33 and a sum of ranks of 3593.00. The difference between the mean ranks, however, was not statistically significant (z = –1.239, $p > .05$), indicating that there was no significant difference between male and female pre-service secondary mathematics teachers in their confidence in using GSP to construct regular polygons.

In contrast, for the Autonomy subscale the male participants had a mean rank of 62.93 and a sum of ranks of 2328.50, whereas the female participants had a mean rank of 49.28 and a sum of ranks of 3449.50. The difference between the mean ranks was statistically significant (z = –2.187, $p < .05$), suggesting that there was a significant difference between the male and female pre-service secondary mathematics teachers in their autonomy of using GSP to construct regular polygons, with the male participants having a higher mean rank than the female participants.

As for the Liking subscale, the male participants had a mean rank of 61.61 and a sum of ranks of 2279.50, whereas the female participants had a mean rank of 49.98 and a sum of ranks of 3498.50. The difference between the mean ranks, however, was not statistically significant (z = –1.857, $p > .05$), indicating that there was no significant difference between the male and female pre-service secondary mathematics teachers in their enjoyment using GSP to construct regular polygons.

Overall, the male participants had a mean rank of 62.03 and a sum of ranks of 2295.00, whereas the female participants had a mean rank of 49.76 and a sum of ranks of 3483.00. The difference between the mean ranks, however, was not statistically significant (z = –1.952, $p > .05$), indicating that there was no significant difference between the male and female pre-service secondary mathematics teachers in their overall attitude towards GSP.

CONCLUSION AND IMPLICATIONS

The results of this study showed that the pre-service secondary mathematics teachers generally expressed confidence in using GSP to construct regular polygons, enjoyed being autonomous when working on GSP construction of regular polygons and expressed enjoyment using GSP to construct regular polygons. Hence, the pre-service secondary mathematics teachers generally showed a positive attitude towards GSP after the one-hour introductory GSP workshop. In general, these results concur with findings of Saiful Azmi, Abdul Ghani and Hajah Siti Jamilah (2001) that undergraduate engineering students developed a positive attitude towards Mathematica (a software system and computer language for use in mathematical applications) after using the software in the Numerical Methods course. The results of this study are also consistent with the study by Cavas and Kesercioğlu (2003), which showed that the majority of teachers had positive attitudes toward computer-assisted learning. In addition, Cavas, Cavas, Karaoglan and Kisla (2009) also found that teachers have positive attitudes toward information and communication technologies in education. This is important because to use GSP effectively in the classroom, pre-service secondary mathematics teachers' attitude toward GSP should be positive and they should be trained in integrating GSP in the teaching and study of mathematics.

However, the mean of the pre-service mathematics teachers' attitude scores for Item 1 was the lowest, indicating that the participants felt that they were not yet good at GSP after the short introductory GSP workshop. The implication of this finding is that a longer introductory GSP workshop should be given to pre-service mathematics teachers so that they can learn and master the more powerful and advanced capabilities of GSP. An alternative strategy is to provide introductory, intermediate, and advanced GSP workshops for pre-service secondary mathematics teachers in a mathematics teaching methods course. This will allow them to develop more confidence, autonomy and appreciation for using GSP, which in turn, will develop more positive attitudes towards GSP.

The results of this study also indicated that there was no significant difference between the male and female pre-service secondary mathematics teachers in their confidence and enjoyment using GSP to construct regular polygons. There was, however, a significant difference between the male and female pre-service secondary mathematics teachers in their autonomy of using GSP to construct regular polygons, with the male participants having a higher mean rank than the female participants. Further, there was no statistically significant difference in the pre-service secondary mathematics teachers' overall attitude towards GSP in terms of gender. Although the literature indicates that there are no consistent results on the attitude towards computer-assisted learning regarding gender (Shapkaa & Ferrarib, 2003), the overall results of this study, concur with Cavas and Kesercioğlu's (2003) finding that there was no significant difference between male and female teachers in attitude toward computer-assisted learning. The overall results of this study are also consistent with the finding from Cavas, Cavas, Karaoglan and Kisla (2009) finding that there was no significant difference between male and female teachers in attitude toward information and communication technologies in education.

This implies that, in general, conducting an introductory GSP workshop in a mathematics teaching methods course is essential for all pre-service secondary mathematics teachers, regardless of gender, for them to gain confidence, autonomy and an appreciation for using GSP to construct regular polygons. However, a longer introductory GSP workshop should be provided to allow pre-service mathematics teachers to learn and master the more powerful and advanced capabilities of GSP. In conclusion, the introductory GSP workshop serves as an essential first step in promoting a positive attitude towards GSP among the pre-service secondary mathematics teachers in a mathematics teaching methods course.

ACKNOWLEDGEMENT

This study was funded by short Term Grant (304/PGURU/6311019), Universiti Sains Malaysia.

REFERENCES

Bennett, D. (1999). *Exploring geometry with the geometer's sketchpad.* Emeryville, CA: Key Curriculum Press.

Cavas, B., & Kesercioğlu, T. (2003). Primary science teachers' attitudes toward computer assisted learning. *Ege Journal of Education*, *3*(2), 35–43.

Cavas, B., Cavas, P., Karaoglan, B., & Kisla, T. (2009). A study of science teachers' attitudes toward information and communication technologies in education. *The Turkish Journal of Educational Technology, 8*(2), 20–32.

Choi, S. S. (1996). *Students' learning of geometry using computer software as a tool: Three case studies*. PhD dissertation, University of Georgia. UMI Publications.

Choi-Koh, S. S. (1999). A student's learning of geometry using the computer. *Journal of Educational Research, 92*(5), 301–311.

Coakes, S. J., & Steed, L. G. (2001). *SPSS without anguish: Version 10.0 for Windows.* Brisbane: John Wiley & Sons Australia, Ltd.

Driskell, S. O. S. (2004). *Fourth-grade students' reasoning about properties of two-dimensional shapes.* PhD dissertation, University of Virginia. UMI Publications.

Elchuck, L. M. (1992). *The effects of software type, mathematics achievement, spatial visualization, locus of control, independent time of investigation, and van Hiele level on geometric conjecturing ability.* Unpublished PhD dissertation, The Pennsylvania State University. Dissertation Abstracts International, 53(05), 1435A. Retrieved 10 April 2004, from http://wwwlib.umi.com/dissertations/fullcit/9226687

Finzer, W., & Jackiw, N. (1998). *Dynamic manipulation of mathematical objects*. Retrieved 2 February 2004, from http://wwwlib.keypress.com/sketchpad/talks /s2k/index.htm

Frerking, B. G. (1995). *Conjecturing and proof-writing in dynamic geometry*. Unpublished PhD dissertation, Georgia State University. Dissertation Abstracts International, 55(12), 3772A. Retrieved 10 April 2004, from http://wwwlib.umi.com/ dissertations/fullcit/9507424

Green, S. B., & Salkind, N. J. (2008). *Using SPSS for Windows and Macintosh: Analyzing and understanding data.* Upper Saddle River, NJ: Pearson Prentice Hall.

July, R. A. (2001). *Thinking in three dimensions: Exploring students' geometric thinking and spatial ability with The Geometer's Sketchpad*. EdD dissertation, Florida International University. UMI Publications.

Kasmawati Che Osman. (2006). *Meninjau penggunaan Geometer Sketchpad (GSP) di kalangan guru matematik sekolah menengah Pulau Pinang*. Unpublished M.Ed. dissertation, Universiti Sains Malaysia, Penang.

Malaysian Ministry of Education. (2003). *Integrated curriculum for secondary schools: Curriculum specifications, Mathematics Form 1.* Kuala Lumpur: Curriculum Development Centre.

McClintock, E., Jiang, Z., & July, R. (2002). Students' development of three-dimensional visualization in the Geometer's Sketchpad Environment. In D. Mewborn, P. Sztajn, D. White, H. Wiegel, R. Bryant, & K. Nooney (Eds.), *Proceedings of the PME-NA Annual Conference* (pp. 739–754). Columbus, OH: ERIC Clearinghouse for Science, Mathematics, and Environmental Education.

Meyer, M. R., & Fennema, E. (1992). Girls, boys, and mathematics. In T. R. Post (Ed.), *Teaching mathematics in grades K-8: Research-based mathematics* (2nd. ed.), (pp. 443–464). Boston: Allyn and Bacon.

Olive, J. (2000). Learning geometry intuitively with the aid of a new computer tool: The Geometer's Sketchpad. *The Mathematics Educator, 2*(1), 1–5. Retrieved 11 August 2003, from http://jwilson.coe.uga.edu/DEPT/IME/Issues/v02n1/5olive.html

Saiful Azmi Haji Husain, Abdul Ghani Haji Naim, & Hajah Siti Jamilah Haji Tengah (2001). Undergraduate students' perceptions of the value of using Mathematica. In M. A. (Ken) Clements, H. H. Tairab, & W. K. Yoong (Eds.), *Energising science, mathematics and technical education for all* (pp. 247–253). Brunei: Education Technology Centre, University Brunei Darussalam.

Shapkaa, J., & Ferrarib, M. (2003). Computer-related attitudes and actions teacher candidates. *Computers in Human Behavior 19*(3), 319–334.

Thompson, E. (2006). Euclid, the van Hiele levels, and the Geometer's Sketchpad. Unpublished master's dissertation, Florita Atlantic University. *Masters Abstracts International, 44(*06), 2529. Retrieved 2 February 2007, from http://wwwlib.umi.com/dissertations/fullcit/1435803

Thompson, E. O. (1992). *Three methods of instruction in high school geometry and the effects they have on achievement, retention, and attitude.* EdD dissertation, Montana State University. UMI Publications.