Effectiveness of a Visual-Spatial Intelligence Teaching Courseware on the Achievement of Underachieving Students in Equivalent Fractions

Keberkesanan Koswer Kecerdasan Visual-Spatial ke Atas Pencapaian Pelajar yang Lemah dalam Pecahan Setara

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Abstract

This research was conducted to test the effectiveness of visual-spatial intelligence teaching courseware to teach "equivalent fraction" topic for Form 1 underachieving students. This courseware uses visual-spatial intelligence which is one of the eight multiple intelligences in multiple intelligence theory by Howard Gardner. The design of this research was pretested and posttested on nonequivalent groups design. The sample involved 57 students that comprised 29 for the treatment group and 28 for the control group. This research also tested whether the use of the courseware could increase visual-spatial intelligence in the Multiple Intelligence (MI) test. Students' perspective towards the courseware in terms of courseware objectives, courseware content, interface design, motivation, and assistance in learning the topic was acquired using questionnaire. ANCOVA test showed that there was a significant effect of the visual-spatial teaching courseware on learning performance compared to Ministry of Education (MOE) courseware after controlling for the effect of pretest (non-homogenous groups). There was a significant increase in the Visual-Spatial Intelligence score in the Multiple Intelligence test from pretest to posttest. Based on the findings, teachers are recommended to use visual representations (visual-spatial intelligence) as much as possible and use less words (linguistic and mathematical intelligence). A teacher should also use one or a few intelligences in each lesson to increase reading in that particular intelligence in the MI test.

Keywords Equivalent fractions proficiency test, multiple intelligence test, visual-spatial teaching courseware, visual representations

Abstrak

Kajian ini telah dijalankan untuk menguji keberkesanan koswer kecerdasan visual- spatial untuk mengajar topik pecahan setara bagi pelajar Tingkatan 1 yang lemah pencapaiannya. Koswer ini menggunakan kecerdasan visual-spatial yang merupakan satu daripada lapan kecerdasan pelbagai dalam teori kecerdasan pelbagai yang dikemukakan oleh Howard Gardner. Kajian ini telah mengguna reka bentuk kumpulan tidak setara dengan kumpulan kawalan ujian pra dan ujian pasca. Sampel kajian meliputi seramai 57 orang pelajar yang terdiri daripada 29 orang untuk kumpulan rawatan dan 28 orang untuk kumpulan kawalan. Kajian ini juga menguji sama ada penggunaan koswer memungkinkan meningkatkan kecerdasan visual-spatial dalam ujian Kecerdasan Pelbagai (MI). Pandangan pelajar terhadap koswer dari segi objektif koswer, isi kandungan koswer, reka bentuk antaramuka, motivasi dan bantuan dalam pembelajaran topik tersebut telah diperolehi melalui soal selidik. Ujian ANCOVA mendapati terdapat kesan signifikan koswer visual-spatial ke atas prestasi pembelajaran berbanding dengan koswer Kementerian Pelajaran Malaysia (KPM) setelah mengawal kesan daripada ujian pra (kumpulan tidak setara). Terdapat peningkatan skor yang signifikan dalam kecerdasan visual-spatial dalam ujian Kecerdasan Pelbagai daripada ujian pra kepada ujian pasca. Berdasarkan dapatan kajian ini, guru adalah digalakkan untuk mengguna representasi visual (kecerdasan visual-spatial) sebanyak yang mungkin dan mengurangkan penggunaan perkataan (kecerdasan linguistik dan matematik). Guru juga seharusnya menggunakan satu atau beberapa kecerdasan dalam setiap pelajaran untuk meningkatkan pembacaan di dalam kecerdasan berkenaan dalam ujian MI.

Kata kunci Koswer visual-spatial, representasi visual, ujian kecekapan pecahan setara, ujian kecerdasan pelbagai

Introduction

Intelligent quotient (IQ) refers to a score given for several standardized intelligence tests. French psychologist, Alfred Binet, developed the first of these in 1905. He constructed the IQ test, as it would later be called, to determine which children might need additional help in scholarly pursuits. Today, the IQ test is commonly based on some model of the Stanford Binet Intelligence scale (Ellis-Christensen, 2008). Unfortunately, the wide use of IQ has negative results in the labeling of students (Gan, 1995).

The traditional view of intelligence is that it is a uniform cognitive capacity that people are borne with. The short-answer test will tell us how smart we are and we cannot change it. An unfortunate use of IQ tests in schools is that it often results in labeling students. The theory of Multiple Intelligences (MI) challenges this view. MI arose as a critique of this standard view of intelligence. Students have several types of intelligences and only two of it (verbal and mathematical skills) are measured in IQ test. Another two types of intelligence, interpersonal and intrapersonal skills, are described as Emotional Quotients (EQ) (Gan, 1995). Research by Gardner (1983) of Harvard University suggested that we all have several intelligences. He identified nine distinct types of intelligences that we all posses to some degree, namely linguistic intelligence, logical-mathematical intelligence, visual-spatial intelligence, bodily-kinesthetic intelligence, musical intelligence, interpersonal intelligence, intrapersonal intelligence, naturalist intelligence, and existential intelligence. We do not have the same strength in each intelligence and we do not have the same combination of intelligences. According to McKenzie (1999) everyone has all the intelligences and we could strengthen each intelligence. Given enough stimuli, each type of intelligence could be strengthened. Studies also found that learners could strengthen their learning preferences, and at the same time, strengthen their weaker skill areas (Seay, 2004).

Gardner argued that our schools and culture focus most of their attention on linguistic and logical-mathematical intelligence. We esteem the highly articulate or logical people of our culture. However, we should also place equal attention on individuals who show gifts in the other intelligences: the artists, architects, musicians, naturalists, designers, dancers, therapists, entrepreneurs, and others who enrich the world in which we live. Unfortunately, many children who have these gifts do not receive much reinforcement for them in school. Many of these kids, in fact, end up being labeled "learning disabled," attention deficit disorder (ADD), or simply underachievers, when their unique ways of thinking and learning are not addressed by a heavily linguistic or logical-mathematical classroom. The theory of multiple intelligences proposes a major transformation in the way our schools are run. It suggests that teachers be trained to present their lessons in a wide variety of ways using music, cooperative learning, art activities, role play, multimedia, field trips, inner reflection, and much more as cited in Armstrong (2000).

According to Keith (2008), many children with learning disabilities appeared to have significant strengths in visual-spatial intelligence. This implies that to teach underachieving students teachers should capitalize on visual-spatial intelligence by using many pictures, diagrams, courseware rich with graphics, videos, printed materials full of graphics, and the such.

According to Moss & Case (1999), many students have problems in learning the concepts of fractions because they cannot establish part/whole relationship and as a result mathematics educators realize that an alternative form of visual representations must be used to represent proportional quantity and standard numerical representation. The learning of fractions is an area of mathematics which students find particularly challenging (Moss & Case, 1999; Pearn & Stephens, 2004). Students have considerable difficulties with fraction equivalence, the notion that different fractions can represent the same amount (Bana *et al*., 1997; Pearn *et al*., 2003). Understanding fraction equivalence is important as it forms the foundation of understanding fraction, addition and subtraction, and enables students to compare and order fractions (Kamii & Clark, 1995).

According to Rao (1991) when software was developed, a lot of emphasis was given to the commercial value so much so that the quality was assessed based on the quality of media used and not on the quality of teaching and learning and expected change in students' behaviour.

There is a growing corpus of research that suggests that the use of technological tools, as a representational modality, improves mathematics learning (Balanskat *et al*., 2006; Laborde *et al*., 2006; Cox *et al*., 2003). Interactive multimedia, such as DLOs and multimedia CDs, could mediate learning through the provision of dynamic, visual representations affording more lucid depictions of mathematical concepts. Students could manipulate already imposed on-screen representations or generate their own representation to amplify their understanding of a mathematical concept (Laborde *et al*., 2006).

When using the concept of Multiple Intelligence in the education system, students could apply different ways of thinking and learning, hence they could require different approaches to learn the same materials. Therefore, the challenge for teachers and tutors is to recognize each learner's strengths and to customize their instructions and activities accordingly (Seay, 2004).

In Malaysia, there is a lack of quality courseware that have pedagogical value designed specially for underachieving students, i.e those students who have problems in learning equivalent fractions, while graphic visualization (visual-spatial intelligence) has not been

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fully utilized in teaching and learning strategy for these students even though they are good at visual-spatial intelligence.

Keeping this in view, this study was conducted to evaluate the effectiveness of the usage of the visual-spatial intelligence teaching courseware previously developed by us for underachieving students on equivalent fractions in the teaching and learning process as compared to courseware developed by the Ministry of Education (MOE), Malaysia. Consequently, this study aimed to ascertain whether using the visual-spatial intelligence teaching courseware could significantly increase the score on visual-spatial intelligent in the Multiple Intelligence (MI) test.

Methodology

A quasi-experimental design was adopted using a pretest and posttest nonequivalent groups design. The two groups involved were nonequivalent because true random assignment was not possible (Johnson & Christensen, 2000) due to the high number of absentees of underachieving students from schools every day. The study was conducted at a secondary school SMK Bandar Tasik Puteri, Rawang, Selangor, Malaysia. Students chosen were from weak classes and their grades for Mathematics in Primary School Scholastic Examination (PSSE) were C, D or E. The population was consisted of 120 Form one students whose score were C, D, or E in Mathematics in PSSE. A total of 57 students from this population were selected as the sample: 29 students in the experimental group and 28 students in the control group.

The first instrument used was MI test that was developed by Chislett & Chapman (2006) designed especially for young people. The instrument was downloaded free from the internet and is popularly used by researchers and teachers. The test would access the individual's perceived multiple intelligences preference. The inventory used both English Language and Malay Language in order to increase the validity by making sure that students understand it. The total score indicates the strength of each type of intelligence. There are two uses for the test. Firstly, it was given before the treatment to distribute students participating into two groups of equal visual-spatial intelligence strength based on the score of visual-spatial intelligence. Secondly, it was given after the treatment to test whether the score of visual-spatial intelligence of the experimental group would increase after treatment was given. The Cronbach Alpha for MI test was 0.81. According to Chua (2006) an instrument reliability test with a Cronbach Alpha value of 0.65 to 0.95 was considered satisfactory.

The second inventory is Equivalent Fractions Proficiency Test. This instrument is a test to measure students' competency in Equivalent Fraction, one of the sub-topic in Fraction Chapter in Mathematics Form 1. The proficiency test was a pretest and posttest given to both experimental and controlled groups to measure the effectiveness of visual-spatial intelligence teaching courseware for underachieving students. The posttests of both groups were analyzed using ANCOVA which was the preferred test for nonequivalent group design (Johnson & Christensen, 2000) while the pretest was used as covariate to statistically adjust the dependent variable (posttest) in order to remove the effects of the portion of uncontrolled variation represented by the covariate (pretest) is a result of nonequivalent groups.

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Courseware Features

The courseware tested in this research was developed by us and it is meant specifically for underachieving students since there was a dire lack of courseware developed for this group (Figure 1). Most courseware was developed for smart schools or average students. Since it was meant for underachieving students, it was designed to be a teaching courseware and not a self-learning courseware. The courseware was meant to be a teaching-learning tool to help the teachers to explain and teach better. It used as little verbal-linguistic intelligence as possible since underachieving students were usually not word-smart. The title had a graphical version to show what the topic meant. This was because graphics enhanced students' understanding and underachieving students needed as much help as they could possibly get (scaffolding). Exercises were given as handouts, i.e, given after the end of each Learning Objective tutorial. The courseware has five learning outcomes to achieve. The courseware was broken down into learning objectives, learning outcomes and tutorial for each learning outcome. Colours played an important part in this courseware; its usage of colours was part of the visual-spatial intelligence.

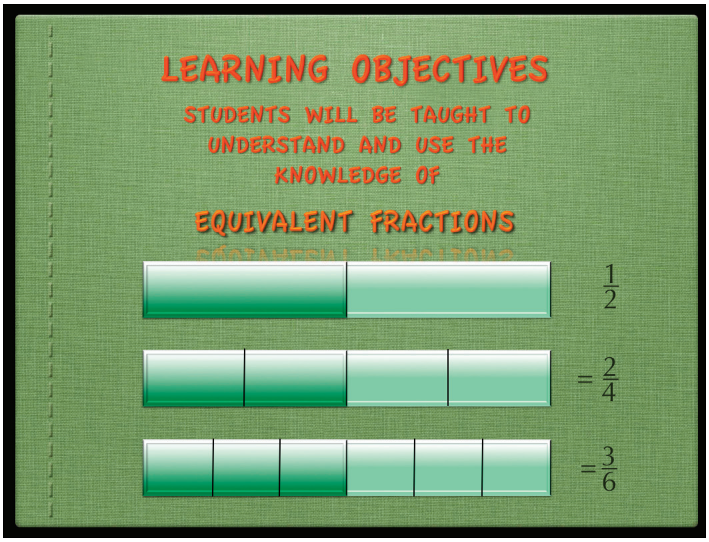

Figure 1 Pieces of informations visualized using diagrams

Results

Effectiveness of courseware

ANCOVA can help us to exert stricter experimental control by taking account of confounding variables to give us a 'purer' measure of effect of experimental manipulation (Field, 2008). Table 1 shows that the adjusted mean of 15.61 for the posttest of the experimental group was higher than the adjusted mean for the control group with a lower value of 13.44. This shows that the treatment group performed better than the control group in the posttest after the effect of covariate (pretest) had been taken into account.

Table 1 Descriptive statistics for ANCOVA with Covariate Dependent Variable (Posttest)

Group	Adjusted Means	Std Error	95% confidence level	
			Lower bound	Upper bound
Experimental	15.61	0.65	14.30	16.91
Control	13.44	0.66	12.12	14.77

Covariates that appeared in the model were evaluated at the pretest values of 12.75

Table 2 shows that there was significantly different performance between the group that used visual-spatial intelligence courseware from the group that used KPM's courseware [F(1,55)=5.29, p=0.03]. The pretest as the covariate was also significant [F(1,55)=90.3, p=0.00] and had contributed 1075.50 of type III Sum of Squares from the total of 13775.0 corrected total, i.e, 7.81%. This reveals that a pretest does have an effect and the observed power of 1.00 was significant to detect the differences between means. According to Sprinthall (2007), an effect size is considered small at 0.20, medium at 0.50, and strong at 0.80 or greater.

Table 2 Test Between-Subjects Effects Dependent Variable (posttest score)

Source	Type III Sum of Squares	df	F	Sig.	Observed Power
Corrected Model	1075.50	2	45.19	0.00	1.00
Intercept	47.10	1	3.96	0.05	0.50
Pretest	1075.50	1	90.37	0.00	1.00
Treatment	62.91	1	5.29	0.03	0.62
Error	642.64	54			
Total	13775.00	57			
Corrected Total	1718.14	56			

Effect of Courseware on Visual-Spatial Intelligent Score in MI test

A paired-sample t-test [t(28)=-2.19, p=0.04] was evaluated using the effect of Visual-Spatial Intelligence Teaching Courseware on Visual-Spatial Intelligence score for experimental group. Table 3 shows that there was a significant increase in the Visual-Spatial Intelligence score from pretest (*M*=12.48, *SD*=2.50) to posttest (*M*=13.28, *SD*=2.40).

Table 3 Increase in Visual-Spatial Intelligence score for experimental group using paired-sample t-test

Test	*M*	SD	Mean difference	df	t	p
Pretest	12.48	2.50	0.80	28	-2.19	0.04
Posttest	13.28	2.40	3.96	0.05	0.50	
Pretest	1075.50	1	90.37	0.00	1.00	
Treatment	62.91	1	5.29	0.03	0.62	

(N=29)

Discussion

Current finding has shown that there was a significant difference in performance between the group that used visual-spatial intelligence courseware and the group that used KPM courseware [F(1,55)=5.29, p=0.03]. This is in line with Anderson & Bower (1973) who stated that memory for some verbal information was enhanced if relevant visuals were also represented or if the learner could imagine a visual image to go with the verbal information. The visual-spatial intelligence teaching courseware used visual representations heavily. Even sentences could be visualized using diagrams and every concept could be explained using visual representations. In this approach, language was not a barrier to underachieving students. If they do not understand English, or even the Malay Language for that matter, they should be able to understand the visuals and graphics which is a universal language.

The findings of this research is also supported by Harding & Terrell (2006) who affirmed that visual learning was a proven teaching method in which ideas, concepts, data and other informations could be associated with images and represented graphically. Visual learners prefer using images, pictures, colours, and maps to organise information and communicate with others and they easily visualize objects, plans and outcomes in their mind's eyes. In addition, visual learning when combined with technology would enable students to clarify thoughts, organise and analyse information, think critically and integrate new knowledge by visually seeing how items could be grouped and organised.

The visual-spatial teaching courseware tested here combined visual learning and technology. Part of the reason for its effectiveness was because students could associate ideas, concepts, data and other informations with the visual representations used in the courseware. Thus the process of understanding the mathematical concepts was made easier. Students could visually 'see' how items could be grouped and organized. This has helped them see relationships and patterns. This is also in line with Silverman & Freed (2007) statement that a visual-spatial learner was a student who learned holistically rather than in a step-by-step fashion. Visual imagery plays an important role in the student's learning process because the individual is processing primarily in pictures rather than words. Their ideas are interconnected. Linear sequential thinking in a heavily linguistic and logical-mathematical environment is particularly difficult for visual-spatial learner and requires a translation of his or her usual thought processes, which often takes more time and more difficult to understand.

The recent pedagogical trend in mathematics, as recommended by the National Council of Teachers of Mathematics (NCTM) (1989), is a common example of support for a visually oriented approach to learning. The NCTM suggested that the use of concrete manipulative devices in learning mathematics significantly aided students to transfer abstract mathematical concepts. Although visual representations alone do not allow for the physical manipulation of objects, they might provide a link between algorithmic procedures and the physical application of those procedures (Ostler, 1995). The findings of this research provided another proof of the effectiveness of the recommendations made by NTCM. The visual representations used in the current courseware provided the link between algorithmic procedures and the physical application of those procedures when the algorithmic procedures were demonstrated using animation of the diagrams first (process of visualization) before numbers were used.

In a report, Gersten *et al*. (2009) recommended that early intervention materials should include opportunities for students struggling with mathematics to work with visual representations of mathematical ideas and interventionists should be proficient in the use of visual representations of mathematical ideas. The systematic use of visual representations and manipulatives might lead to statistically significant or substantively important positive gains in mathematics achievement. Four studies used visual representations to help pave the way for students to understand the abstract version of the representation. For example, one of these studies taught students to use visual representations such as number lines to understand mathematics facts. The four studies demonstrated gains in mathematics facts and operations and word problem proficiencies, and provided evidence that using visual representations in interventions was an effective technique.

An examination on the posttest done by the experimental group in this study showed that some students drew visual representations on their papers to help them visualised the fractions while students in the control group appeared to rely on application of algorithm/ calculation only. The use of visual representations might have enabled the students in the experimental group who had forgotten the algorithm/calculation to solve the problems by reasoning it out with a drawing. The visual-spatial intelligence teaching courseware used visual representations to illustrate the algorithm/ calculation.

The visual-spatial teaching courseware provided the scaffolding needed by underachieving students by using graphics to help them visualized the concepts. According to Branford *et al*. (2000), the more capable teacher could provide the scaffolds i.e graphics in the courseware, so that with asistance the learner could accomplish the tasks that he or she could otherwise not complete, thus helping the learner through the Zone of Proximal Development. The visual-spatial teaching courseware used the representational scaffold by using the animated diagrams that enabled students to see and visualize the procedures concretely rather than just memorizing a series of steps using numbers. This helped students to devise visual representations to solve mathematics problems as seen in the posttest papers of some of the students in the experimental group. With the help of the graphics, students could understand, for example, why 1/2 is equivalent to 2/4. If this concept was to be taught using algorithm/calculation solely, underachieving students would find it difficult to see why the two fractions were equal spatially. After learning using the visual-spatial teaching courseware, students need not have to rely on algorithm/calculation solely but could use the mental pictures that they had created.

This research also found that there was a significant increase in the Visual-Spatial Intelligence score from pretest (M=12.48, SD=2.50) to posttest [(M=13.28, SD=2.40), t(28)=-2.187, p=0.04]. Hence the courseware was effective in increasing the visual-spatial intelligence of the students who were being taught using this courseware.

This finding supports the idea that intelligences could be nurtured and strengthened, or ignored and weakened. Gardner (1993) also stressed that recognizing and nurturing all of the varied human intelligences were of utmost importance. Our courseware has proven that given enough stimuli, the visual-spatial intelligence could be nurtured and increased.

This findings also supported McKenzie (1999) who stressed that everyone has all the intelligences and we could strengthen each intelligent. This finding is also in line with Seay (2004) who reported that some studies found learners could strengthen their learning preferences, and at the same time, strengthen their weaker skill areas.

Implication of the Findings on the Teaching and Learning Processes

When some of the students in the experimental group drew visual representations on their posttest paper, this implied that this method was effective especially when students did not understand or forgot the algorithms/calculations. An alternative method was available for them to solve the problems beside the traditional algorithm/calculation methods. It could also mean that they were using the visual representations to help understand the mathematics problems better and to have a clearer picture in their minds.

This implies that teachers should use as much graphics/visuals/diagrams as possible in their teaching practices. This is especially so for underachieving and medium students who need as much scaffolding as possible. Teachers must move away from a heavily linguistic and mathematical-logical approach in their teaching, i.e. teachers must use diagrams/visual/graphics heavily and avoid giving notes full of words. All the diagrams/visual/graphics would help students to form mental pictures which would make the process of understanding concepts a lot easier and faster. Without understanding the concepts, it would just be rote learning which would avoid understanding of a subject. In rote learning students might still perform in tests and examinations but would be unable to practice in real life situations or working environment. Using diagrams/visual/graphics could ensure proper understanding of concepts since students could easily see the whole picture and how items are connected to each others and where they fit in the whole picture. This is the opposite of linear sequential thinking in a heavily linguistic and logical-mathematical environment where students memorize steps and notes/points but fail to see the whole picture.

A visual-spatial learner is a student who learns holistically rather than in a step-by-step fashion. Visual imagery plays an important role in the student's learning process**.** Because the individual processes primarily in pictures rather than words, ideas are interconnected like a web. Linear sequential thinking, the norm in American education, is particularly difficult for this person and requires a translation of his or her usual thought processes, which often takes more time (Silverman & Freed, 2007).

When using visual-spatial intelligence in the teaching and learning processes, teachers could better ensure proper understanding of concepts and thus would be easier for students to perform in tests and examinations, not because of memorization but because of understanding the concepts. What is more important is that the learning will have a long lasting effects that would go beyond tests and examinations to real life situations and working environments.

Scaffolding allows students to perform tasks that would normally be slightly beyond their ability without the assistance and guidance from the teacher. Appropriate teacher supports could allow students to function at the cutting edge of their individual development. Scaffolding is therefore an important characteristic of constructivist learning and teaching (Murphy, 1997). The usage of teaching courseware, instead of self-access courseware, is better for underachieving students since they need as much scaffolding as possible. This teaching courseware is in line with constructive learning theory. Underachieving students need help from teachers to understand the concepts being learnt. Concept learning is very crucial for any student, what more for underachieving students. Rahimi *et al*. (2007) stressed that as professionals, teachers must always ensure that the use of any instructional tools, software included, is the best way to teach a particular concept to a particular student or group of students. Software will never replace teachers; the professional, human, decision-making abilities of caring teachers will always be required to guide student learning.

Another implication is that teacher should aim to use all the different intelligences when preparing their lesson plans. The most economical and practical approach is to use one or two intelligences in one lesson and use another intelligence in the next lesson. In this way, teachers can eventually increase all the eight types of intelligence of their students.

Conclusion

The visual-spatial intelligence teaching courseware had been proven to be an effective tool in the teaching and learning processes of underachieving students. The finding of this research has shown that there is a window of hope for this students. Teachers and educators just need to change their teaching and learning strategy by using visual representations to better serve this big and neglected market of underachieving students.

References

Armstrong, T. (2000). Multiple Intelligences. Retrieved September 12, 2009, from http://www.thomasarmstrong.com/multiple_intelligences.php

Anderson, T. (2000). Multiple Intelligences. Retrieved September 12, 2009, from http://www.thomasarmstrong.com/multiple_intelligences.php

Balanskat, A., Blamire, R. & Kefla, S. (2006). The ICT impact report: A review of studies of ICT impact on schools in Europe. European Communities.

Bana, J., Farrell, B., & McIntosh, A. (1997). Student error pattern in fraction and decimal concepts. Paper presented at the People in Mathematics Education. Proceeding of the twentieth Conference of Mathematics Research Group of Australasia, Rotorua, New Zealand.

Chislett V., & Chapman A. (2006). Multiple Intelligence Test – based on Howard Gardner's MI Model. Retrieved March 15, 2009 from http://www.businessballs.com/freepdfmaterials/free_multiple_intelligences_test_manual_version.pdf

Chua Yan Phiaw. (2006). Asas Statistik Penyelidikan. Kuala Lumpur: Mc Graw Hill

Cox, M., Webb, M., Abbott, C., B., Beauchamp, T. & Rhodes, V. (2003). ICT and attainment: A review of the research literature (no 17). London: Becta.

Ellis-Christensen, T. (2008). What is IQ. Retrieved March 6, 2009, from http://www.wisegeek.com/whay-is-iq-intelligence-quotient.htm

Gan, S.L., (1995). Multimedia Environmental Education Courseware for Promoting Cooperative Learning and Higher-Order Thinking Skills. Retrieved March 6, 2009 from http:/www.pppl.upm.edu.my~ganslcdc1.html

Gardner, H. (1983). Frames of the Mind: The Theory of Multiple Intelligences. New York: Basic Books, INC.

Gersten, R., Beckmann, S., Clarke, B., Foegen, A., Marsh, L., Star, J.R., & Witzel, B. (2009). Assisting students struggling with mathematics: Response to Intervention (RtI) for elementary and middle schools (NCEE 2009-4060). Washington, DC: National Center for Education Evaluation and Regional Assistance, Institute of Education Sciences, U.S. Department of Education. Retrieved from http://ies.ed.gov/ncee/wwc/publications/practiceguides

Harding G. & Terrell S. L. (2006). Strategies of alleviating math anxiety in the visual learners. Retrieved February 10, 2009, from http://polaris.umuc.edu/ctl-content/webtycho/math/plan4.pdf

Johnson, B., & Christensen, L. (2000). Educational Research: Quantitative and Qualitative Approach. Massachusetts: Allyn & Bacon.

Kamii, C., & Clark, F. B. (1995). Equivalent fractions: Their difficulty and educational implications. The Journey of Mathematical Behavior, 14(4), 365.

Keith, K. L. (2008). Nuture your child's visual-spatial intelligence. Retrieved October 7, 2008 from http://childparenting.about.com/cs/k6education/a/childvisualspat.htm

Laborde, C., Kynigos, C., Hollebrands, K. & Strasser, R. (2006). Teaching and learning geometry with technology. In A. Gutierrez & P. Boero (Eds.), Handbook of research on the psychology of mathematics education: Past, present and future (pp. 275-304). Rotterdam, The Netherlands: Sense Publishers.

McKenzie, W. (1999). Multiple Intelligence Inventory. Retrieved December 27, 2008 from http://surfaquarium.com/Mi/inventory.htm

Moss, J., & Case, R. (1999). Developing children's understanding of the rational numbers: A new model and an experimental curriculum. Journal for Research in Mathematics Education, 30(2), 122-147

Murphy, E. (1997). Characteristics of constructivism teaching and learning. Retrieved December 28, 2008 from http://www.cdli.ca/~elmurphy/emurphy/cle3.html

Ostler, E. (1995). A study of visual models on mental computation on fractions for pre-service elementary teachers. Questia Online Research Journal for Education, Vol. 116, 1995

Pearn, C., Stephens, M., & Lewis, G. (2003). Assessing rational number knowledge in the middle years of schooling. In C. Australian Association of Mathematics Teachers (Ed.), Mathematics – Making waves (pp. 170-178). Brisbane

Pearn, C., & Stephens, M. (2004). Why you have to probe to discover what year 8 students really think about fractions. Paper presented at the Mathematics Education for the Third Millennium: Towards 2010, Townsville, South Carolina.

Rahimi, M. S., Noraini, I., Loh, S. C., Ahmad Zabidi, A. R., & Norjoharuddeen, M. N. (2007). Evaluation Of Courseware For Teaching And Learning Of Form One Mathematics And Science. MDEC Volume 1, December 2007.

Rao. G.S. (1991). Pembelajaran Berbantukan Komputer. Kuala Lumpur: Fajar Bakti.

Seay, G., (2004). Identifying and Using Multiple Intelligence. Retrieved March 6, 2009, from http://gse.berkeley.edu/faculty/gsaxe/Research.html

Silverman, L. K. & Freed, J. N. (2007). The visual spatial learner. Retrieved October 7, 2008, from http://www.dyslexia.com/library/silver1.htm

Sprinthall, R. (2007). Statistical Analysis. Boston: Massachusetts. Allyn and Bacon.