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Association between Brain Hemisphericity, Learning Styles and Confidence in Using Graphics Calculator for Mathematics

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This paper presents the preliminary results of a study conducted to investigate the differences in brain hemisphericity and learning styles on students' confidence in using the graphics calculator (GC) to learn mathematics. Data were collected from a sample of 44 undergraduate mathematics students in Malaysia using Brain-Dominance Questionnaire, Index of Learning Style Inventory, and Confidence in Using GC to Learn Mathematics Questionnaire. Statistical analyses revealed that the sample differ significantly in their hemispheric preference and learning styles. In addition, sequential-global and sensing-intuitive learning styles were found to associate significantly with brain hemisphericity. However, there was no significant association between brain hemisphericity with gender, race, and program of study. Finally, the study also revealed that GC confidence ratings are not significantly different across brain hemisphericity as well as learning styles.

Keywords: Brain Hemisphericity, Graphics Calculator, Instructional Tool, Learning Styles

INTRODUCTION

Hand-held technology such as the graphics calculator (GC) is increasingly used in many mathematics schools and colleges worldwide. Integrating GC in the curriculum has a huge potential and can make mathematics learning more enjoyable and more accessible. While it has been claimed that GC empowers students to visualize mathematics (Arcavi & Hadas, 2000; Cunningham, 1991), there is still a need to better understand the issues involved in terms of how the GC shapes the students' learning of mathematics and the interplay between the tool and the subject.

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In the teaching and learning process, cognitive neuroscientists noted that right-brain dominant people prefer visual, spatial and analogical processing while left-brain dominant people prefer verbal, logical, linear and sequential processing. Realizing the importance of the connection between brain and mathematical thinking, researchers are attempting to link learning styles with hemispheric dominance (Seng & Yeo, 2000). Sadler-Smith and Badger (1998) maintained that cognitive style is a fundamental determinant of an individual's behaviour in organizational processes and routines. They stressed that cognitive style can explain why people with the same abilities, knowledge, and skills performed differently in the organization. In order to explain the differences in performance between students in the same classroom when incorporating a new instructional tool, it is pertinent to explore the connection between brain hemisphericity, learning styles as well as technical confidence with the tool.

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Table 1. Characteristics of the learners, learning styles and brain hemisphericity.*

Types of learner	Learning styles	Brain hemisphericity
Active	Retains and understands information best by discussing in group, applying it or explaining it to others.	
Reflective	Prefers to think about and work out something alone.	
Sensing	Likes to learn facts, solve problems by well-established methods. Good at memorizing facts and doing hands-on (laboratory) work. Dislikes complications as well as surprises. Resents being tested on material that has not been explicitly covered in class. Doesn't like courses that have no apparent connection to the real world.	Left-brain
Intuitive	Prefers discovering possibilities and relationships. Likes innovation and dislikes repetition. Good at grasping new concepts and is more comfortable with abstractions and mathematical formulations. Doesn't like courses that involve a lot of memorization and routine calculations.	Right-brain
Visual	Remembers best what is seen in pictures, diagrams, flow charts, time lines, films, and demonstrations.	Right-brain
Verbal	Get more out of words from written and spoken explanations.	Left-brain
Sequential	Tends to gain understanding in linear steps, with each step following logically from the previous one in a logical stepwise paths in finding solutions.	Left-brain
Global	Can solve complex problems quickly or put things together in novel ways once he/she has grasped the big picture without seeing connections. May have difficulty explaining how he/she did it.	Right-brain

*Table 1 is an abridgment between Felder and Solomon's Learning Styles (2001) and McCarthy's (1987) 4MAT System

OBJECTIVES OF THE STUDY

This study is conducted to examine the differences in brain hemispheric processing modes and learning styles among 44 undergraduates who undertake the specialized mathematics course using the GC. The course was developed by the School of Mathematical Sciences at the Universiti Sains Malaysia (USM). In this program, the students were acquainted with the capabilities of the GC as an instructional tool. Specifically, the study aims to investigate the relationship of brain hemisphericity and learning styles on the students' confidence in using the GC to learn mathematics.

LITERATURE REVIEW

Cognitive neuroscientists generally held that brain hemisphericity or brain dominance is the tendency of an individual to process information through the left hemisphere or the right hemisphere or in combination. It was pointed out further that left hemispheric dominant learners are analytical, verbal, linear and logical, whereas those right-hemispheric dominants are highly global, visual, relational, and intuitive. Closely related to brain hemisphericity is the learning style or the preferred way in which individuals learn. McCarthy (1987) purported four types of learners (innovative, analytic, common sense and dynamic) in association with two different brain modes (left or right). Similarly, Felder and Solomon (2001) classified learners into four different domains according to their learning styles. The four domains consist of the active-reflective learners, the sensing-intuitive learners, the visual-verbal learners and the sequential-global learners. Table 1 summarizes the characteristics of the learners, their learning styles and brain hemisphericity in accordance to Felder and Solomon (2001) as well as McCarthy's (1987) proposition.

DESIGN OF THE STUDY

The special topic course in GC at USM is developed for final year pre-service teachers and students in mathematics. The course has attracted an overwhelming response from students since its inception in 2001. Amongst the course objectives are to acquaint students with computer algebra system (CAS) calculators and its capabilities, to understand the relevance of calculator technology in the teaching and learning of mathematics and sciences, and to familiarize students with the issues involved in the use of calculator technology in the classroom.

Table 2. Mean of GC confidence and T-tests for all domains

Types of domain	N	Mean	Std. Deviation	t	Sig (2-tail)
Left-brain	30	.8087	.43442	-.204	.839
Right-brain	10	.8391	.30884		
Reflective	18	.7874	.35413	-.529	.600
Active	24	.8533	.42942		
Intuitive	6	1.0145	.26327	1.277	.209
Sensing	36	.7935	.40778		
Verbal	1	1.0000	.	.443	.660
Visual	41	.8208	.39957		
Global	11	.8024	.41719	-.219	.828
Sequential	31	.8331	.39453		

The course content includes topics from calculus, linear algebra, differential equations, and statistics. Students were not required to purchase GCs; each student had a calculator checked out for the duration of the course. Alternating interactive lectures and in-class exploration activities are the primary teaching modes of the course. This is complemented with laboratory assignments. The course culminates with a group project designed to foster students' knowledge and critical understanding of principles in mathematics and statistics.

For the cohort of 2005/2006, data were collected using 15-item Brain-Dominance Questionnaire (Mariani, 1996), 44-item Index of Learning Style Inventory (Felder & Solomon, 2001) and 23-item Confidence in Using GC to Learn Mathematics Questionnaire (Ali & Kor, 2004). Brain-Dominance Questionnaire and Index of Learning Style Inventory were administered to the respondents at the commencement of the course. The GC Confidence questionnaire was administered at the end of the course after students had mastered most of the GC skills. All items are 5-point Likert scale, and each item receives a score in the range of –2 to +2. Thus a positive mean score indicates a favourable response. To carry out the analyses, Chi-square tests on goodness-of-fit and tests of independence as well as T-tests of means were conducted using SPSS.

RESULTS OF THE STUDY

From a total of 44 questionnaires administered, two were incomplete and were subsequently discarded. Analysis revealed that 71% of the sample were left-brain dominant (n=30) whereas 24% (n=10) were right-brain dominant and the remainders (n=2) were whole-brain learners. As the whole-brain learners were very small in number, statistical tests were not conducted on this group.

Results showed that the sample differs significantly in hemispheric dominance and learning styles at 1% level of significance. In particular, almost 66% of the sample belongs to slight to moderate left-brain category. Similarly, data showed that most of the samples belong to mild active, moderate sensing, strong visual, and mild sequential learning styles (Fig.1).

On the other hand, mean GC confidence ratings were computed across different brain dominance and types of learners. In Table 2, results showed that learners who are "reflective" and "sensing" scored the lowest in confidence in using GC to learn mathematics. Also, T-tests conducted on the pairs in each domain showed no significant differences in the means of GC for all domains at 5% level of significance. The results indicated that there were no significant differences in GC confidence across brain hemisphericity as well as learning styles.

Looking at Tables 3 and 4, further analysis found that brain dominance associates significantly with the sensing-intuitive (p-value=0.015), as well as sequential-global learning styles (p-value=0.013).
The results are in accordance with McCarthy's (1987) proposition that left-brain learners are "sensing" and "sequential" while right-brain learners are "intuitive" and "global". However, there was no statistical significant association between brain hemisphericity with active-reflective as well as visual-verbal learners. Furthermore, no statistical significant association between brain hemisphericity with gender, race, and program of study was reported.

CONCLUSIONS

The genesis of our research into brain dominance and learning styles was the result of our inquisition about whether the competency skill in mastering the GC is brain dominated. In response to Steen's (1999) query regarding the neural mechanism of mathematical thought, we seek to understand the biology of the brain which could scientifically improve an individual's mathematical performance.

Table 3. Chi-Square tests on brain dominance and sensing-intuitive learning styles.

		Intuitive-sensing		Total
		Intuitive	Sensing	
Type of Brain Dominance	left brain	2 (4.4)	29 (26.6)	31
	right brain	4 (1.6)	7 (9.4)	11
Total		6	36	42

Numbers in parenthesis is the expected count.

Table 4. Chi-Square tests on brain dominance and sequential-global learning styles

		Sequential-global		Total
		Global	Sequential	
Type of Brain Dominance	left brain	5 (8.1)	26 (22.9)	31
	right brain	6 (2.9)	5 (8.1)	11
Total		11	31	42

Numbers in parenthesis is the expected count.

To date, no related research has yet been conducted to integrate both brain hemisphericity and learning styles in a mathematics classroom that incorporate the use of instructional tool such as the GC. Although the preliminary results of this study showed that there was no statistically significant difference in the GC confidence scores and the brain hemisphericity as well as learning styles, there were evidences of association between learning styles and brain dominance. It was found that most respondents were left brain dominated. In addition, results revealed that left brain individuals tend to be sensing and sequential learners.

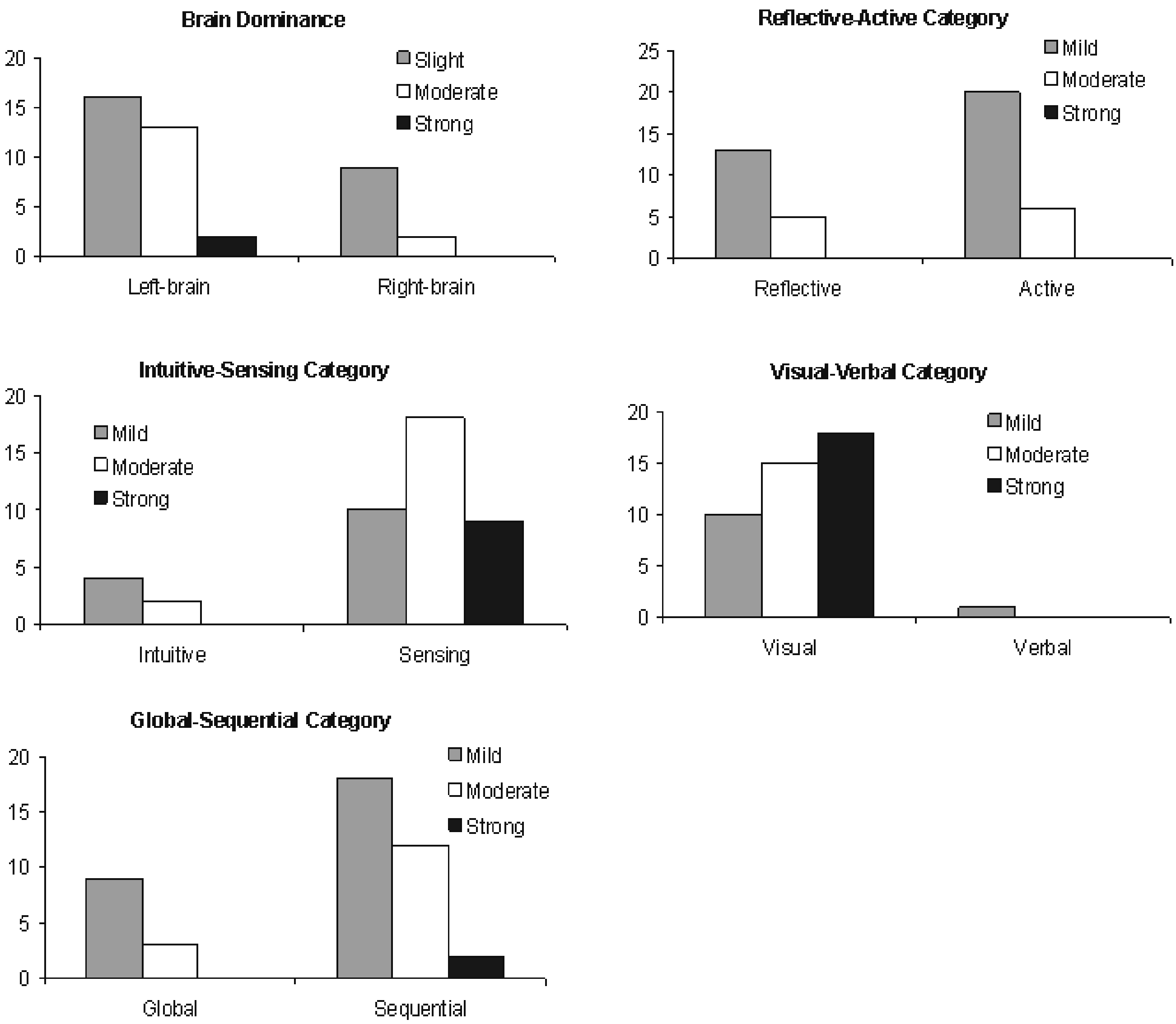

Figure 1. Frequency of categories in each domain

Lastly, we believe that the significance of our study could help enlarge the dimensions of research that examine the area of incorporating new technological tool in the teaching and learning of mathematics.

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