RELATIONSHIPS BETWEEN CREATIVITY, CRITICAL THINKING, GENDER, MATHEMATICAL ABILITY AND PATTERN RECOGNITION AMONG PRIVATE SCHOOL STUDENTS IN SINGAPORE

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ABSTRACT

In Singapore, students who wish to sit for the GCE 'O' level examinations would usually register themselves as school candidates and study in one of the Singapore public or autonomous schools to prepare for the high-stakes examinations. However, there were some students who, due to various reasons, choose to enrol themselves in preparatory courses offer by private schools. Many of these private school students were academically weaker in their studies (as compared to their counterparts in public schools), and many lacked the ability to recognize prominent patterns, which was an important cognitive skill for academic successes. A starting point to solve the problem was to determine possible relationships of pattern recognition with other cognitive abilities. Reviews of literature found evidences that creativity and critical thinking were two cognitive skills connected to pattern recognition. Therefore, the main objective of this study was to investigate the relationships of creativity and critical thinking skills of private school students with pattern recognition. A correlation research design was used to investigate the relationships between these cognitive skills, with mathematical ability as the mediating variable and gender as the moderating variable. The project involved the administration of survey questionnaires to the GCE 'O' level private school students. The instruments used for the study include a creativity test (modified Creativity Selected Elements Questionnaire), a critical thinking test (modified Cornell Critical Thinking), a mathematical ability test and a pattern recognition test. The main bulk of quantitative analysis was done using SMART-PLS Structural Equation Modelling (SEM) version 2. The results of the study showed that creativity was a weak predictor of pattern recognition ($\beta = .074$, $t(203) < 1.96$, $f^2 = .016$) but critical thinking was a good predictor ($\beta = .326$, $t(203) > 1.96$, $f^2 = .278$). It was also found that the mediating effect of mathematical ability and

the moderating effect of gender were insignificant. This study contributed to the research in Singapore private education, particularly from the perspectives of the teachers and school administrators. It also provided the recommendation on how lessons should be conducted in order to incorporate elements of critical thinking and pattern recognition.

APPROVAL PAGE

I certify that I have supervised / read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and was fully adequate, in quality and scope, as a thesis for the fulfilment of the requirements for the degree of Doctor of Philosophy.

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DECLARATION

I hereby declare that the thesis submitted in fulfilment of the PhD degree was my own work and that all contributions from any other persons or sources were properly and duly cited. I further declare that the material has not been submitted either in whole or in part, for a degree at this or any other university. In making this declaration, I understand and acknowledge any breaches in this declaration constitute academic misconduct, which may result in my expulsion from the programme and/or exclusion from the award of the degree.

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DEDICATION

First and foremost, I would like to dedicate this thesis to my parents, Mr Ling Wee Peow and Mdm Lee Noi Cheng, who both had left me for a better world. While my father passed on in 2015 due to lungs failure, I lost my beloved mother in 2018 due to a sudden cardiac arrest. I was in the midst of my data collection and the news of her abrupt depart, coupled with other challenging family and work-related commitments, had caused me to be on the brink of depression. I firmly believe that it was the spiritual support from my parents where I found the strength to continue the journey.

I would also like to thank my wonderful wife, Chrissie Ang, who has been giving me tremendous support throughout my research journey starting from day one. Not only has she given birth to two adorable princesses, she has managed to relieve me of some of my parental duties with the effort that she spent taking care of them while I was busy with my research.

I sincerely hope that this thesis will make all of you proud of me.

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CHAPTER 1

INTRODUCTION

Background of the Study

The Singapore educational system comprised compulsory education of 10 to 11 years, with six years of primary education and four to five years of secondary education. Majority of the children would enrol in primary one at the age of seven, and at the end of their six years of primary school education they will sit for the Primary School Leaving Examination (PSLE). The PSLE results streamed the children into three main streams in secondary schools, which were the Express, Normal (Academic) and Normal (Technical).

Students who scored better in their PSLE would usually enter into the Express stream, where they embark on a four-year course to prepare themselves for the GCE 'O' level examinations. Students who were less academically-inclined would enter into the Normal (Academic) stream, where they would take the GCE 'N' level examinations at the end of the fourth year, and if they perform well enough, they can be eligible to sit for the GCE 'O' level examinations at the end of the fifth year. The Normal (Technical) stream caters to students who were academically very weak. At the end of the fourth year, Normal (Technical) students would sit for the GCE 'N' level examinations, and their results determine if they can continue their studies at the Institute of Technical Education (ITE) or to leave the system and start working.

Foreign students who wish to sit for the GCE 'O' level examinations in Singapore have two options to do so. They can sit for the Ministry of Education Admission Exercise for International Students (AEIS) entrance examinations to

attempt to enter into the main stream Singapore public schools. AEIS examinations assess the student's level of English proficiency, numerical ability and reasoning ability (MOE, 2016). Admission into public schools through AEIS was, however, not guaranteed. It depends mainly on two factors: the performance of the candidate during the AEIS examinations and also the number of vacancies in public schools. The other option was to enrol themselves into private schools. In this case, the foreign students can register themselves as private candidates to sit for the examinations together with the mainstream Singapore students.

Private schools in Singapore accept mainly four groups of students from diverse academic and cultural backgrounds into their GCE 'O' level preparatory courses. The first group of students were the foreigners who came from countries such as Malaysia, Indonesia, Philippines, Vietnam, China, Kazakhstan etc. The second group of students were the local Singaporean students who sit for the GCE 'O' level examinations but did not do well enough to qualify for the courses that they wish to study at tertiary institutions beyond the 'O' levels (for example, the polytechnics or junior colleges). The third group of students were the people who sat for the GCE 'N' level examinations but fail to get promoted to the 5^{th} year to take the GCE 'O' level examinations due to their unsatisfactory results. The fourth group of students were the young working adults, who dropped out of the education system when they were younger due to various reasons, but now wish to continue their studies in search of better career prospects.

The GCE 'O' level preparatory course entrance requirements for private schools were slightly different for the local and international students. Local students will need to complete at least secondary three, the GCE 'N' level or other equivalent academic standards while international students need to complete middle school or its

equivalent (Stalford Academy, 2019). The minimum age must be 15 years old as of 1st of January in the year of taking the GCE 'O' level examinations. In addition, the international students must have demonstrated proficiency in English as English was the main medium of instruction and assessment.

In addition, private school students can also seek the help of learning centres to better prepare them for the high stake examinations. More and more learning centres, such as Aedno Learning Studio, provide specialized academic training to help students cope with the academic rigour of the GCE 'O' level examinations.

Private Schools and Learning Centres in Singapore

There were many different types of private schools in Singapore. They mainly differ in sizes, the courses they offer and the qualifications that they confer. Many of these private schools confer diploma and advance diploma certifications and at the same time, work together with established foreign universities to conduct distance undergraduate and post-graduate programmes. Some of the private schools in Singapore were: the Management Development Institute of Singapore (MDIS), Kaplan Singapore, BMC International College and TMC Academy.

Besides offering diploma, bachelor and post-graduate courses, some of these private schools also conduct preparatory courses to prepare students for the GCE 'O' and 'A' levels examinations. These courses were intensive in nature, and were designed to be completed in 12 months, 18 months or at most 24 months. The minimum duration for a similar course in public schools will take about two years. For example, Kaplan Singapore prepares students for the GCE 'O' level examinations with a period of 12 months of preparatory course (Kaplan, 2018). International students can choose to enrol in the 24-months program, which was less intensive.

When it comes to recruitment of teaching staff, each private school has its own hiring policies and requirements. In general, all lecturers and associate teachers who were engaged to teach in the private education sector must be suitably qualified in the field that he or she was teaching, and they must be registered with the Committee of Private Education (CPE).

In recent years, there were also learning centres that have started to enrol private school students to prepare them for the GCE O level examinations. Stalford Academy and Penciltutors were two such examples. These education centres have the humble beginnings offering just private group tuition to students mainly in the public schools and international schools. However, as part of their expansion plans, some of these centres have began to offer GCE 'O' level exam-preparatory programs and coaching services to private school students.

The main difference between a learning centre and a private school was that a private school can also offers diploma level and degree level programs while a learning centre will usually offer tuition and exam-preparatory services for the GCE, IGCSE, IB or equivalent levels examinations.

Number of O level Private School Students in Singapore

The number of students who take their GCE O levels as private candidates (private school students who have registered for the O level examinations were called private candidates) have fallen over the years, probably due to more alternative options to further their studies. The year 2018 saw 1,389 private candidates who sat for the 2018 GCE 'O' levels examination (Ang, 2019). In 2019, this number dropped to 1262 (Ang, 2020).

MOE introduced a new regulation in 2017 to monitor the number of local students who wish to enrol into the private schools' GCE O level preparatory courses. The regulation requires all Singaporeans or Singapore permanent residents to seek approval from MOE before they can enrol in the preparatory courses. The application requires about two to three months to process. In view of this, the number of private candidates was anticipated to drop further in the coming years.

Importance of Pattern Recognition and Related Studies in Singapore

Many students (both public and private school students) have the potential to perform well in their studies. One of the skills they need was the ability to recognize patterns among topics and develop connections between concepts. Good pattern recognition skills allowed an individual to spot trends or to understand the relationships among different things in real life (Kidd *et al*., 2012). The skills were also critical elements necessary to achieve future academic successes (Claessens & Engel, 2013). Unfortunately, not every student possessed good pattern recognition skills.

A study was conducted on 504 Singapore primary four public school students on their abilities in performance-based tasks (Ang, Boo & Toh, 2005). The study revealed that while majority of the students involved in the study were capable of basic pattern recognition, many of them encounter difficulties in activities that require them to make generalization and also recognize patterns beyond what they can physically observe (Ang *et al.,* 2005).

Another more recent study was done on the performance of 104 Singapore public school students on their success rates in pattern generalization tasks (Chua & Hoyles, 2014). All of them were Grade 8 students (secondary two). At the end of the

study, it was found that only 70% of the students were able to construct the generalization rule for each pattern tasks (Chua & Hoyles, 2014).

Pattern Recognition Ability of the Private School Students

How was the level of pattern recognition skills of the private school students compared to the public school students? A preliminary study using a simple pattern recognition test (Appendix 1) was administered to a group of 61 private school candidates (mean age of 17.1 years) in April 2016 and a group of 45 public school candidates (mean age of 16.1 years) in June and July 2016 to compare their levels of pattern recognition. All of the respondents were students who sat for their GCE 'O' level examinations in October 2016. The pattern recognition test comprised eight short multiple-choice questions, which can be completed in about 15 minutes. Table 1.1 shows the percentages of respondents who were able to identify the correct patterns for each of the 8 test items.

Table 1.1

Private vs Public School Students for Preliminary Study

Private School Students			Public School Students		
Test item	No. of correct identifications	Percentages	Test item	No. of correct identifications	Percentages
1	48	78.7%	1	37	82.2%
2	47	77.0%	2	35	77.8%
3	55	90.2%	3	40	88.9%
4	***35***	***57.4%***	4	***33***	***73.3%***
5	44	72.1%	5	39	86.7%
6	44	72.1%	6	37	82.2%
7	44	72.1%	7	37	82.2%
8	50	82.0%	8	38	84.4%
Mean Score / 8		6.02	Mean Score / 8		6.67
Sample size, N = 61			Sample size, N = 45		

At the end of the preliminary study, an independent samples t-test was done to compare the means between the private candidates with that of the public candidates. Results revealed that the t-test was significant ($t(104) = -2.089$, $p < .05$). The result implied that there was a difference in the pattern recognition ability between the private and the public school students. The mean difference of -0.65 indicated that based on the responses from the samples drawn, the public school students fare better at pattern recognition than the private school students.

Despite the fact that most private school students have received several years of formal education (for students who enrolled into a private school's O level preparatory course, they should at least finish their secondary three education) and that pattern recognition and generalization has been part of the Singapore mathematics curriculum since primary school, their level of pattern recognition remained significantly weaker as compared to the counterparts in public schools. Yet, there was little study done to address the gap; and no viable solution has been proposed or research study conducted so far (Chua & Hoyles, 2014). Obviously, this was an issue that needed to be further investigated.

An important point to take note was that the results of the above preliminary study were not an indication of the overall academic ability of the private school students in Singapore. The sample size was too small to be representative of the entire private school student population. The preliminary study merely served as a starting point to identify a potential problem for further research to be carried out. It was not the intention of the researcher to undermine the general academic abilities of the private school students.

Rationale of the Study

To help the private school students perform better at the GCE 'O' level examinations, this study has identified several important variables in an attempt to establish significant correlations between them. The following discussions highlighted the rationale on why the different variables were chosen and also the need to conduct the study.

The first and most important variable identified in this study was pattern recognition. Pattern recognition was an important cognitive skill required to do well in subjects such as mathematics, languages, sciences or even the humanities (Claessens & Engel, 2013). Many private school students appear to be weak in their pattern recognition ability. It was also found that people who were proficient in pattern recognition were able to better apply this skill in mathematical-related fields and language-related fields (Kidd, Gadzichowski, Gallington, Boyer & Pasnak, 2012). The pattern recognition variable was the variable that the researcher was most interested in gaining further understanding and predicting (Flannelly, Flannelly & Jankowski, 2014), and therefore, it was identifed as the dependent variable.

Creativity and critical thinking were two independent variables identified for the study. The rationale to choose creativity and critical thinking was because both were important higher-order cognitive skills needed for the 21st Century (Norris, 2018). A search on the literature revealed significant relationships between creativity and pattern recognition (Kozhevniknov *et al*., 2013; Liu, 2007; Verstijnen, 1998) as well as relationships between critical thinking and pattern recognition (Matthee & Turpin, 2019; Harris & Spiker, 2012; Kurzweil, 2012; Chen *et al*., 2011). The researcher was interested to investigate the possible effects of creativity and critical

thinking on pattern recognition (dependent variable), and therefore they were chosen as the independent variables (Flannelly *et al.*, 2014).

Mathematical ability has been identified as the mediating variable in this study. The main rationale was because it was found through literature reviews that mathematical ability may be able to explain the relationships between pattern recognition, creativity and critical thinking (Trinter *et al.*, 2015; Ramírez Uclés, del Río Cabeza & Flores Martínez, 2018). At the same time, it has long been a fact that pattern recognition was closely related to mathematical ability (Sternberg, 1975; Lee & Freiman, 2006), and therefore warranted further investigation.

Last but not least, gender was identified as the moderating variable. The main reason why gender was chosen as the moderator variable for this study was because past studies revealed that gender may be able to influence the strength of the relationships between pattern recognition, creativity and critical thinking (Kozhevniknov *et al.*, 2013; Liu, 2007). Therefore, it was worthwhile to investigate the moderating effect of gender on the relationships connecting the above three main cognitive abilities.

However, to improve the overall academic performance of the students, can we simply train the students in their pattern recognition, assuming that pattern recognition was able to influence the results? Was it necessary that we tap into other cognitive abilities to uncover significant relationships with pattern recognition, and ultimately improve overall academic performance? The issue was: the teaching of pattern recognition techniques during mathematics classes was very inadequate to see any result due to the limited time students spent in the classrooms. From the school's perspective, organising of pattern recognition workshops was neither economical nor