Study Habits and the Mathematical Performance of 15-year-old Students in Singapore

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Abstract

This study aims to understand the study habits of 15-year-old Singapore students, in relation to their PISA 2009 mathematics scores. The analysis will address which control strategies helped Singapore students improve their scores and contrast it with a similar study conducted in Canada by Shipley (2012). While the top three control strategies were similar, there was a significant increase in mathematics scores for Singapore students. The paper will also contextualise learning strategies in relation to the lower difference in scores that Singapore male students obtained when they studied more than three hours, and had used strong versus moderate study habits.

Keywords: PISA 2009, learning strategies, Singapore.

Introduction

Singapore managed a strong debut in the triennial Programme for International Student Assessment (PISA) in 2009. This fever developed into a frenzied fascination with Singapore's as well as other high performing education systems and their definitive key to success (see Lee & Lee, 2012; Lee, Lee, Low, & Tan, 2014). PISA claims to be able to measure the degree to which 15 year-old students acquire knowledge and skills, specifically in mathematics, science and reading which are essential for today's knowledge society (OECD, 2010). By basing its claim on providing a standard to which nations can compare how well their students are faring, the Organisation for Economic Co-operation and Development (OECD) has also provided a database to measure and correlate many different variables that allow for a better understanding on how students learn.

These variables were attained from the PISA 2009 assessment and questionnaire that 5,283 15-year-old students in Singapore took part in. This paper leverages on the data obtained from Singapore's participation in PISA 2009 to understand the approaches—memorization, elaboration, and control strategies—that students used to learn and how it relates to their PISA mathematics scores. This paper aims to examine what learning strategies work, and for which gender, when students learn outside of their normal schooling hours.

Hours Spent on Studying and Doing Homework

Singapore students who spent more than three hours on learning mathematics or by doing mathematics homework did worse than those who spent less than three hours (see Table 1). This difference may not have been by much for both genders but males experienced a 24 point drop compared to an insignificant three point increase for females. Shipley (2012) conducted a similar analysis and found that both male and female Canadian students had higher mathematics scores when they studied for more than three hours. Perhaps, it is how Singapore students use that time to learn that made the difference.

Table 1: Average Mathematics PISA scores by hours spent per week studying or doing homework, and by gender, Singapore, 2009

	Number of hours spent per week studying /doing homework, math		Difference in average scores
	Less than three hours	Three hours or more	
Both Genders	566	555	-11
Males	571	547	-24
Females	560	563	+3

Learning Strategies

Many factors affect learning (see Wang, Haertel, & Walberg, 1993). Therefore, there are many who have attempted to define learning strategies. As first surmised by Weinstein and Mayer (1983), research on learning strategies is a means to help students effectively handle the torrent of information flooding their mental process. Therefore in their seminal paper, Weinstein and Mayer (1986) defined a learning strategy based on two parts—(1) the ability of a learner to engage with their behaviour and thoughts, as well as (2) having the ability to aid in the learner's encoding process. Hence, Weinstein, Jung, and Acee (2010) posited that "a learning strategy is any behavioural, cognitive, metacognitive, motivational, or affective process or action that facilitates understanding, learning, and meaningful encoding into memory… it includes almost any psychological variable" (p. 323).

In order to demonstrate their definition, Weinstein and Mayer's (1986) pivotal study featured an extensive literature review and relied on data obtained by fieldwork done by other researchers. They summarised the results of each study and then codified the learning strategies into eight categories. The first six categories were multiplications of 'basic' and 'complex' added to the three main cognitive terms: rehearsal, elaboration, and organization. The last two terms namely comprehension monitoring and affective strategies have led to studies on control strategies namely in metacognition and self-regulation. The parsimonious nature of the types of learning strategies, in relation to the PISA 2009 questionnaire is described below.

Memorization / Rehearsal Strategies

Students use rehearsal strategy the most as it is relatively the easiest (Weinstein & Mayer, 1986). A basic rehearsal example is when students memorize the order of planets from the sun by repeatedly voicing the planets (Weinstein & Mayer, 1986). Rehearsal is useful for the most basic of memorisation that requires only surface level processing but would not be useful for anything deeper or more sophisticated (Weinstein et al., 2010). Complex rehearsal, however, may involve underlining the important parts of what is being learned, then rehearsing to try to recall it (Weinstein & Mayer, 1986). Other examples may include (1) highlighting / underlining, (2) rereading, and (3) keyword mnemonic (see Dunlosky, Rawson, Marsh, Nathan, & Willingham, 2013). It is also through mnemonics, that learning strategies was able to thrive (see Weinstein et al., 2011). If rehearsal, specifically the passive type, had to be labelled with a commonly used learning technique, it would be similar to rote memorization. The mind's function may be running but devoid of thought or cognition, similar to a trance state. As with many other similar characteristics to the questions posed to students in the PISA questionnaire, it is therefore safe to assume that memorization is akin to rehearsal strategies.

Elaboration Strategies

This learning strategy is the largest and most diverse (Weinstein et al., 2010). Students connect their heart and soul in forming and associating their past experiences, knowledge, attitudes, and beliefs to the learning task, so as to ensure meaningful encoding into their memory (Weinstein et al., 2010). Compared to rehearsal, elaboration involves higher level cognition and not just verbatim recalling of what was learnt. Therefore, elaboration is akin to meaningful learning.

Karpicke and Grimaldi (2012) stated that meaningful learning helps to produce organised, coherent and integrated mental models, which allow learners to apply their knowledge and make inferences. Hopkins (2010) parsimoniously stated that meaningful learning is anything that makes sense to the learner and might be encoded much more easily and more differently than surface knowledge or memorization. As such, deep learning strategy involves (1) understanding key concepts, (2) relating new learning with relevant experience from previous personal experiences, (3) organise new information, (4) relate ideas, and (5) monitor their understanding of the material to be learnt (McInerney, Cheng, Mok, & Lam, 2012). Thus complex elaboration comes from oft used but influential methods in upper-level inclusive classrooms such as applying what students had learnt to new tasks—(1) where learners teach each other, (2) use perspective taking, (3) use visualization, (4) create analogies, (5) compare and contrast two related concepts, (6) highlight similarities and/or differences, and (7) create and respond to questions on the source material (Kaur, 2012; Weinstein et al., 2010).

Organisation Strategies

Organisation strategy users attempt to reconfigure the new information to better structure, characterise, and represent it (Weinstein at al., 2010). Students who use this strategy would direct their own active learning and be able to organise information into different schemes, hierarchies, and categories so that it would be meaningful encoded into their memory (Weinstein at al., 2010). Training in organisation strategies also led to significant improvements in recall as users may select information better and construct more meaningful relations with the new information (Weinstein & Mayer, 1986). Organisation effects are similar to elaboration and helped learners increase their (1) concentration, (2) focus, (3) interest, (4) motivation, (5) enjoyment, and (6) overall positivity towards the learning task and content (Weinstein at al., 2010). This is perhaps why organisation can be categorised with elaboration, as it involves elaborating and reorganising new material to a graphical format (Weinstein et al., 2011).

Control Strategies / Comprehension Monitoring / Metacognition

The first six strategies can be summarised as cognitive-based where learners use rehearsal, elaboration, and organisation to make cognitive progress; metacognition, however, helps students monitor it (Flavell, 1979; Tan, Dawson & Venville, 1998). Joo, Seo, Joung, and Lee (2012) added that individuals need metacognition as cognitive strategies are not as sufficient in their effectiveness and relevance for information. Lories, Dardenne, and Yzerbyt (1998) saw it differently, stating that cognitive activities are monitored and controlled by metacognitive activities.

Metacognition can be seen in light of its operational term—comprehension monitoring or meta-learning, which requires learners to (1) establish their learning goals or targets, (2) actively monitor, and (3) assess whether the learning goals were met, then to be aware and (4) adapt accordingly, and if needed, to (5) modify the strategy so as to meet the intended concrete objective (e.g., Flavell, 1976; Montgomery, 2009; Moss & Brookhart, 2012; Pintrich, Anderman, & Klobucar, 1994; Weinstein & Mayer, 1986; Zimmerman & Schunk, 2011). This active process requires learners to self-evaluate whether the learning objective has been met, or in other words, learners checking their own learning progress by self-review (Weinstein et al., 2010). This form of active self-assessment can be done through a wide variety of techniques that include (1) self-corrections when reading a text, (2) underlining words that a learner cannot understand, (3) generating questions before reading a text, (4) reviewing notes mentally, (5) attempting to use new information in other ways, and (6) applying it as a principle or method (Weinstein & Mayer, 1986; Weinstein et al., 2010). Henceforth, metacognition can be seen as a form of self-regulation, which would be reviewed next. While self-regulated learning is a field onto itself, the goal of metacognition is to establish whether the accessible memory of learners have been encoded with the new information and in essence whether understanding has been achieved (Weinstein et al., 2010). Given its perceived similarity, this is perhaps why Weinstein and Mayer (1986) linked metacognition with self-regulation and labelled them under management strategies. Subsequently, PISA labelled them as control strategies.

Control Strategies / Affective / Self-Regulation

Unless students learn to regulate their own affective state, they might not be able to fully utilise all the above-mentioned learning strategies that were discussed. Weinstein and Mayer (1986) determined that the emphasis in this area of research is on how learners use strategies to maintain concentration, focus, and motivation as well as to manage performance anxiety and time effectively. Vermunt and Vermetten (2004) perceived this strategy as affective activities that are centred around emotions, that derive from learning and may either positively, neutrally and even negatively impact the process of learning.

In Weinstein and Mayer's (1986) original study, self-regulation was first labelled as affective learning. Although this has since been revised whereby the evolved definition revolved round how learners manage to maintain control over their own cognition, emotion, motivation, and environmental factors to best learn (Weinstein et al., 2010; 2011). With this control, self-regulated learners can choose, implement, monitor, adapt, evaluate their approach to learning, as well as crucially manage their time (Weinstein et al., 2010; 2011). Ee, Moore, and Atputhasamy (2003) found that students in Singapore who knew self-regulation strategies were more likely to use it, as they found that it helps their achievement.

Method

This paper concerns itself with the three main strategies that were discussed earlier. The PISA 2009 questionnaire consisted of 13 randomly listed statements which represented three main groups of strategies: (1) memorization, (2) elaboration, and (3) control strategies. Students were asked to express the degree of strategy use (almost never, sometimes, often, and almost always) when they were studying. The publically available dataset was then obtained and using SPSS, the tables for this paper were created using the same methodology in Shipley's (2012) analysis. Additionally, the median scale reliabilities for the use of elaboration and control strategies were higher than that of memorization (OECD, 2012). Coupled with a growing relationship of control strategies and mathematics (see Desoete & Veenman, 2006), the five individual statements were separated to ascertain which yielded substantial gains in PISA 2009 mathematics scores.

Discussion

As with Shipley's (2012) analysis on Canadian students, the top three control strategies are exactly the same (see Table 2). Similarly, each of the top three control strategies registered more than half of a PISA proficiency level (37.5 points) or more when often/almost always was compared to never/sometimes. Unlike Shipley's (2012) analysis, the bottom two strategies changed positions though their differences in scores were nearly identical.

Both male and female students that specifically use "I make sure that I remember the most important points in the text" recorded a higher difference in scores than the bottom two strategies combined.

The differences in mathematics PISA 2009 scores were also nearly equal for both genders in terms of "I try to figure out which concepts I still haven't really understood" and "I check if I understand what I have read". Notably, the gap between the third and fourth control strategy is 12 points for males and 16 points for females. This suggests that the top three control strategies were much more effective for Singapore students than that of Canadian students where the gap between third and fourth control strategy is one point for males and six points for females. Thus, Singapore students that used the top three control strategies were more likely to improve.

Table 2: Increases in average PISA Mathematics scores associated with using (often or always) control strategies, by gender, Singapore, 2009

Control strategies	Difference in average scores	
	Males	Females
I make sure that I remember the most important points in the text	61	55
I try to figure out which concepts I still haven't really understood	47	48
I check if I understand what I have read	42	39
I start by figuring out exactly what I need to learn	30	23
When I don't understand something I look for additional information to clarify	29	21

Significant difference in average scores was also noticed when analysis revealed that Singapore students, as with their Canadian counterparts, used two or more of the top three control strategies (see Table 3). Respectively, male and female students in Singapore also benefitted with a difference in score that is similar to the top control strategy.

Table 3: Average Mathematics PISA scores associated with the use of the top three control study strategies, and by gender, Singapore, 2009

Mathematics studying or homework	Use of top three control study strategies		Difference in average score
	Used none or only one	Used two or more, often or almost always	
Both Genders	517	574	57
Males	519	578	59
Females	515	570	55

Combination of Time and Control Strategies

Having examined how control strategies might improve PISA scores, a more holistic insight might form when it is linked with time. Shipley (2012) posited that students can be grouped into three study habits. A fourth category of those who use none or one of the top three strategies and studied three hours or more per week was eliminated as it made up less than 5% of Canadian students (Shipley, 2012). In Singapore, that proportion is close to 13% but without any means to compare, the analysis should be shifted back to Shipley's (2012) three groups and their result.

Table 4: Average Mathematics PISA scores associated with different study habits, by gender, Singapore, 2009

Average Mathematics Score					
Weak study habits		Moderate study habits		Strong study habits	
Males	Females	Males	Females	Males	Females
522	515	584	570	563	575
Studies less than three hours per week in math and uses none or only one of the top three control strategies.		*Studies less than three hours per week in math and uses two or more of the top three control strategies.*		*Studies more than three hours or more per week in math and uses two or more of the top three control strategies.*	

Compared to moderate study habits, Singapore male students did not benefit from using strong study habits (see Table 4). Instead, they experienced a 21 point drop in their average mathematics score. This is in sharp contrast to Shipley's (2012) study where male students experienced gradual gains when comparing the three different study habits. Whereas female students experienced a five point increase which is less than the Canadian students. Although the key is to move students away from weak study habits and that is where the gains can be seen.

Shipley's (2012) assertion that students have to move away from weak study habits is exemplified by gains of at least 41 points when comparing it with strong study habits for males. Likewise, a more significant 60 points for females was found. Yet, the highest gain can be seen for male students that use moderate study habits over weak study habits, with female students experiencing a sharp increase in scores as well.

Conclusion

This analysis found that Singapore students who spent more than three hours studying and who had weak study habits had lower PISA 2009 mathematics scores. This diverges slightly from Shipley's (2012) analysis that more time spent studying translated to significant differences in all PISA subjects.

The use of control strategies, specifically the top three did show significant score improvements with males reporting higher gains than females. Also in line with Shipley's (2012) analysis, students that had weak study habits had lower scores when individually compared to moderate and strong study habits. Though more research has to be done on whether factors such as the improper use of time or learning strategies might have affected the lower PISA Mathematics scores for male students that had strong study habits.

Considering that about 10% of male and female students had weak study habits, it is worth considering how best to equip male students for moderate study habits that produce significant score gains. If female students adopt strong study habits, they can benefit likewise. Ultimately, this analysis has provided a gateway to understanding how Singapore students learn, the amount of time spent and how it relates to mathematics scores.

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