Causal Model of Mathematics Achievement as Estimated by Cognitive and Metacognitive Learning Strategies, Informational and Non-informational Resources Management

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ABSTRACT

This study explored a causal model that best fits student's achievement in Algebra. Specifically, it investigated the causal relationships of students' cognitive, meta-cognitive learning strategies, informal and non-informal resources management to their achievement in Algebra. Using test and adopted survey questionnaires, data were gathered from 63 freshmen students of a College in Davao City during the first semester of 2013-2014. Path analysis was utilized to identify the best fitting causal model as examined by the following goodness of fit indices: Chi-square/degrees of Freedom, Root Mean Square of Error Approximation, Tucker-Lewis Index and Comparative Index. Fortunately, a casual model of achievement that best fits the data was found. This model suggests that the metacognitive learning strategies have direct and indirect effects through cognitive learning strategies to the achievement. Moreover, both non-informational and informational resources management have indirect effects via meta-cognitive strategies to the achievement.

Keywords: *Achievement, Cognitive and Metacognitive Learning Strategies, Informal and Non-informal Resource Management, Path Analysis*

INTRODUCTION

Mathematics learning depends so heavily on the direction of the students' effort, and one way in which individual students go about mathematics learning is how he/she uses the learning strategies. As studies suggest, learning strategies play a crucial role in mathematics learning (Liu & Lyn (2010) and effective use of learning strategies can greatly improve student achievement (Protheroe & Clarke, 2008; Riggs & Gil-Garcia, 2001).

Therefore, the goal of education is to help the students take control over of their learning process and know how, when, and where to use various learning strategies (Chang, 2010). Students must be able to manage their own learning. To do this, they need to be able to establish goals, to persevere, to monitor their learning progress, to adjust their learning strategies as necessary and to overcome difficulties in learning. Students who leave school with the autonomy to set their own learning goals and with a sense that they can reach those goals are better equipped to learn throughout their lives (OECD, 2004).

The spectrum of learning strategies expands from simple repetition to internal motivation of learners. Categorically stating, learning strategies include four major components: Cognitive and meta-cognitive strategies, and informational and non-informational resources management. Cognitive strategies include repetition, organizing new language, summarizing meaning, guessing meaning from context, using imagery for memorization. Meta-cognitive strategies refer to the learners' awareness of their own knowledge and their ability to understand, control, and manipulate their own cognitive processes. Informational resources management focuses on the learners exploratory and communication behavior on instructional resources. Non-informational resources management includes the learners' effort regulation and their help seeking behavior. The present study merged these sub-clusters and employed the four major groups of strategies as validated by Karadeniz, Buyukozturk, Akgun, Cakmak, and Demirel, (2008).

Statement of the Problem

For several years of teaching mathematics in a College in Davao City, the researchers observed that many students do not know how to manage their own learning. In particular, their students in class do not use much of their class time taking notes and reviewing the lessons. Also, they observed that most of their students did not manage efficiently their study time. Most students were not prepared for class and that they relied too much on the lectures for the acquisition of knowledge. If students do not practice the skills learned, they will have difficulty retaining information and will be far from achieving proficiency in the skill. Consequently, the result is low grades. In fact, studies indicated that unsuccessful students had less usage of effective learning strategies (Chang, 2010; Bland, 2005; Cho & Ahn, 2003; McWhaw & Abrami, 2001).

The researchers believe that to help students for successful learning to occur, teachers, and the students must understand the learning process. It is critical to identify the students' strengths and weaknesses as well as students' repertoire of learning strategies. Learning strategies are important because it can enhance a student's ability to achieve academically (Protheroe & Clarke, 2008).

Many students have difficulty learning Algebra and they often earn low grades in Algebra courses. This study examined factors that affect students' achievement in Algebra courses. The following were the research questions that guided this investigation:
1. Is there a causal relationship among students' cognitive and meta-cognitive learning strategies and their achievement in Algebra courses?
2. Is there a causal relationship between informational and non-informational resources management and their achievement in Algebra courses?
3. Which model does best fit students' achievement in Algebra courses?

FRAMEWORK

This study was anchored on the theory of Self-Regulated Learning (SRL) by Zimmerman (2000). Self-regulated learning is a process that assists students in managing their thoughts, behaviors, and emotions in order to successfully navigate their learning experiences. This process occurs when a student's purposeful actions and processes are directed towards the acquisition of information or skills. Generally, models of SRL are separated into phases. One popular cyclical model discusses three distinct phases: Forethought and planning, performance monitoring, and reflections on performance (Pintrich & Zusho, 2002; Zimmerman, 2000).

Self-regulated learners' proactive qualities and self-motivating abilities help to distinguish them from their peers. Research shows that self-regulated students are more engaged in their learning. These learners commonly seat themselves toward the front of the classroom (Labuhn, Zimmerman, & Hasselhorn, 2010), voluntarily offer answers to questions (Elstad & Turmo, 2010), and seek out additional resources when needed to master content (Clarebout, Horz, & Schnotz, 2010).

Most importantly, self-regulated learners also manipulate their learning environments to meet their needs (Kolovelonis, Goudas, & Dermitzaki, 2011). For example, researchers have found that self-regulated learners are more likely to seek out advice (Clarebout et al., 2010) and information (De Bruin et al., 2001) and pursue positive learning climates (Labuhn et al., 2010), than their peers who display less self-regulation in the classroom. Due to their resourcefulness and engagement, it is not then surprising that findings from recent studies suggest that self-regulated learners also perform better on academic tests and measures of student performance and achievement (Schunk & Zimmerman, 2007; Zimmerman, 2008).

In a study of high school students, Labuhn et al. (2010) found that learners who were taught SRL skills through monitoring and imitation were more likely to elicit higher levels of academic self-efficacy (i.e., confidence) and perform higher on measures of academic achievement compared to students who did not receive SRL instruction. It seems as though SRL can make the difference between academic success and failure for many students (Graham & Harris, 2000; Kistner, Rakoczy, & Otto, 2010).

METHODS

Research Design

The researchers employed the alternative models approach of structural equation modeling. In this study, three causal models were developed to investigate the correspondence among the four different learning strategies such as cognitive, meta-cognitive, non-informational and informational resources management towards academic achievement. These models were then tested for best fit on the data gathered.

Participants

The participants of this study were the freshmen students of a College in Davao City. They were enrolled in Algebra course during the first semester of 2013-2014 under the Upward Mobility Program of the College. From the two Algebra classes, a total of 63 respondents participated in the study.

Research Instruments

Two instruments were used in the study. The first instrument includes the teachers' constructed test questionnaire in Algebra (30 items, Cronbach alpha=0.813) which covers topics on real number systems and algebraic expressions. This instrument was utilized to measure the academic achievement of the students.

On the other hand, the second instrument was patterned from Mathematics Learning Strategies Scale (Liu and Lin, 2010). In this scale, the learning strategies were classified into Cognitive strategies (18 items, Cronbach alpha = 0.921), meta-cognitive strategies (12 items, Cronbach alpha =0.890), non-informational resources management (25 items, Cronbach alpha =0.874), and informational resources management (13 items, Cronbach alpha =0.932).

Data Analysis

Path analysis was utilized to identify the best fitting causal model as examined by the following goodness of fit indices: Chi-square/degrees of Freedom, Root Mean Square of Error Approximation, Tucker-Lewis Index and Comparative Index. In identifying the best fitting model, all the indices must consistently fall within acceptable ranges. Chi-square/degrees of freedom value should between 0 and 2, with its corresponding p-value greater or equal to 0.05. Root Mean Square of Error Approximation value must be less than 0.05 and its corresponding pclose value must be greater or equal to 0.05. The other indices such as Normed Fit Index, Tucker-Lewis Index, Comparative Index and Goodness of fit index must be all greater than 0.95.

RESULTS AND DISCUSSIONS

Tests of Hypothesized Model 1

The first causal model depicts the interrelationship among the four learning strategies such as cognitive, metacognitive strategies, non-informational and informational resources management and their direct effects on academic achievement. This causal model 1 in terms of standardized solution is presented in Figure 1. As shown in the model, 52% of the variation of the achievement is explained by the combined effect of self-cognitive, metacognitive strategies, non-informational and informational resources management. In addition, Regression weights were estimated to measure the effects between exogenous and endogenous variables. The model suggests that at 0.05 level of significance, cognitive (β=0.33), informational (β=0.42) and non-informational learning strategies (β=0.56) are predictors of achievement. In addition, cognitive and informational (r=0.46) as well as non-informational and metacognitive (r=0.90) were positively correlated. This indicates that if students could efficiently use their cognitive, informational and non-informational learning management, then they would more likely to have better achievement in Algebra.

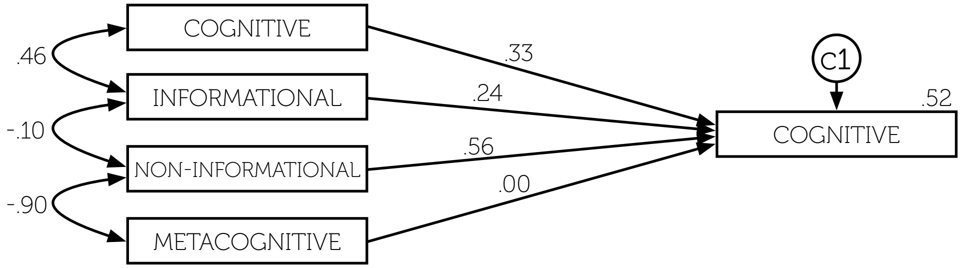

Figure 1. Causal model 1 standardized solution

The goodness of fit indices of Model 1 was examined. As displayed in Table 1, results revealed that the model did not fit to the data. This is indicated by CMIN/DF = 8.969 with its corresponding p-value = 0.000 and RMSEA = 0.543 with pclose = 0.000. Likewise, the other indices such as NFI, TLI, CFI, and GFI also suggest a poor fit of model to the data as all the index values do not fall within each criterion.

Table 1. Goodness of fit measures of causal model 1

INDEX	CRITERION	MODEL FIT VALUE
CMIN/DF	0 < < 2	8.969
P-VALUE	> .05	0.000
NFI	> .95	0.748
TLI	> .95	0.177
CFI	> .95	0.753
GFI	> .95	0.797
RMSEA	< .05	0.543
PCLOSED	> .05	0.000

Tests of Hypothesized Model 2

The second causal model describes the relationship between non-informational and informational resources management and their direct and indirect effects as mediated by metacognitive and cognitive strategies towards academic achievement. Figure 2 portrays the model 2 in standardized solution. The model indicates that the non-informational (β=0.47) and informational resources management (β=0.21) and cognitive strategies (β=0.28) have significant direct contribution to the achievement. It further shows that non-informational (indirect beta weight=0.23*0.77*0.28) and informational resources management (indirect beta weight=0.81*0.77*0.28) indirectly impact the achievement thru the mediation of metacognitive and cognitive strategies. It is also revealed that the explained variance of the combined effect of these four learning strategies to the achievement reached 64%.

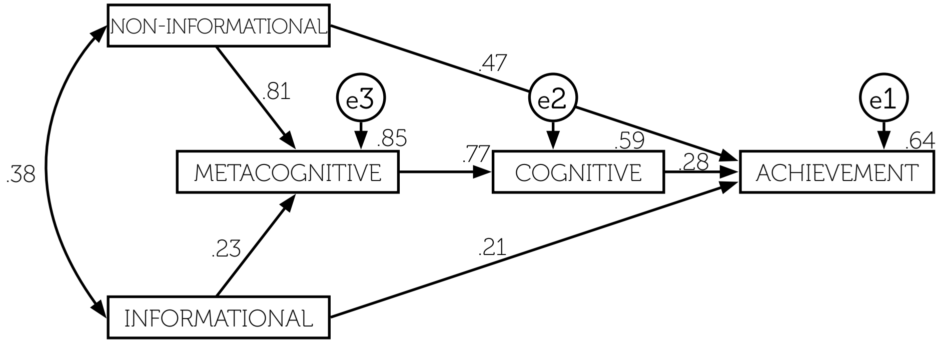

Figure 2. Causal model 2 standardized solution

The model fitting was calculated as being highly acceptable as presented in Table 2. The chi-square divided by the degrees of freedom is 0.100 with the probability level of 0.96. This indicates a very good fit of the model to the data. This also strongly supported by RMSEA index which is less than 0.05, with its corresponding pclose-value > 0.05. Likewise, the other indices such as NFI, TLI, CFI, and GFI were found to consistently indicate a good fit model as their values, all fall within each criterion.

Table 2. Goodness of fit measures of causal model 2

INDEX	CRITERION	MODEL FIT VALUE
CMIN/DF	0 < < 2	0.100
P-VALUE	> .05	0.960
NFI	> .95	0.997
TLI	> .95	1.090
CFI	> .95	1.000
GFI	> .95	0.996
RMSEA	< .05	0.000
PCLOSED	> .05	0.964

Tests of Hypothesized Model 3

The third causal model explains the inter-causal relationship among cognitive, metacognitive strategies, non-informational and informational resources management with the academic achievement. Figure 3 presents the causal Model 3 in standardized solution. Results revealed that non-informational and informational resources management are positively correlated (r=0.38). In addition, both these non-informational and informational resources management indirectly influence achievement thru metacognitive and cognitive strategies. Nevertheless, it illustrates the direct effects of cognitive (β=0.30) and metacognitive (β=0.51) strategies on achievement.

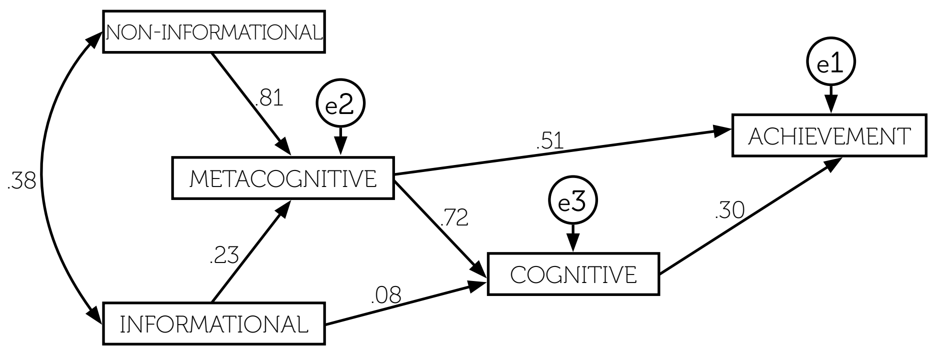

Figure 3. Causal model 3 standardized solution

Examination of the goodness of fit of causal model 3 is portrayed in Table 3. The fit indices NFI, TLI, CFI and GFI were all in the acceptable ranges indicating a good data fit of the model. In similar fashion, the indices CMIN/DF and RMSEA with their p-values also meet the criteria which indicate a good fit for the model.

Table 3. Goodness of fit measures of causal model 3

INDEX	CRITERION	MODEL FIT VALUE
CMIN/DF	0 < < 2	1.032
P-VALUE	> .05	0.389
NFI	> .95	0.961
TLI	> .95	1.997
CFI	> .95	0.997
GFI	> .95	0.999
RMSEA	< .05	0.035
PCLOSED	> .05	0.425

CONCLUSION

Among the three identified models, causal model 2 best fits the data as evident in the goodness of fit statistics which fall within the range of different indices. The model demonstrates that both informational and non-informational resources management have direct effects to the achievement of students in Algebra. This finding suggests that the resources management play an important role for the students to attain better achievement in Algebra. In other words, the students needs to utilize any available resources such as notes, books and any related online lecture materials to help improve their understanding and increase their academic performance. Hence, the instructors need to facilitate the students in getting resources whether from books or online to provide them the necessary materials and substantiate their learning. This is supported by Liu and Lin (2010) that students should get assistance from their instructors on how to find resources whether online or printed in order to make the learning of students a continual process.

On the other hand, the model also shows that both informational and non-informational resources management have indirect effects to the achievement via meta-cognitive and cognitive strategies. This means that the influence of informational and non-informational resources management can be interceded by their mental processes and their ability to understand, control, and manipulate their own cognitive functions. While most of the students in this study find Algebra as a difficult subject, they were also amenable that they will have better performance if they improve their study habits, spending more time and attention to the subject, and the use of appropriate learning approaches. Thus, this finding suggests that instructors should also concentrate on how to enhance the student's learning strategies to learn Algebra better. This is aligned to the notion of Liu and Lin (2010) that the instructors should provide more support to help students in their difficulties in mathematics and improved their learning strategies.

Based on the findings, it is recommended that instructors may use this study to learn more about the students learning strategies use so that they will better understand how to offer effective learning strategy instruction. The results of the research would offer an opportunity for them to reflect on their teaching approaches and see if they need to make adjustments.

Nevertheless, the research only looked at the achievement of freshmen students at Algebra courses. A study should be conducted using a larger population of college students that includes other mathematics courses. This would help identify the influence of students' use of learning strategies to mathematics learning and determine if there are grade related.

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