Vol. 17 · July 2014
Print ISSN 2012-3981 • Online ISSN 2244-0445
doi: http://dx.doi.org/10.7719/jpair.v17i1.283
Journal Impact: H Index = 3 from Publish or Perish

JPAIR Multidisciplinary Research is produced
by PAIR, an ISO 9001:2008 QMS certified
by AJA Registrars, Inc.

Metacognitive Knowledge Predicts Success in Problem Solving Transfer

BEVERLY T. REGIDOR
ORCID No. 0000-0003-1883-8154
beverlytabayregidor@gmail.com
University of the Immaculate Conception
Davao City, Philippines

ABSTRACT

Problem solving skills play a vital role in solving real life problems. This study was conducted to determine the influence of metacognitive and motivational aspects of problem solving skills to the students' success in problem solving transfer. Furthermore, it determined what aspect of the problem solving skills predicts success in problem solving transfer. The descriptive correlation method was used to determine the relationship of the metacognitive and motivational aspects of the problem solving skills and the students' success in problem solving transfer. The respondents of the study are the fourth-year high school students of Davao Central College, Philippines. There are three instruments used in the study: 1) The Metacognitive Awareness Inventory which measures their awareness in metacognitive skills such as knowledge and regulation, the 32-item Academic Intrinsic Motivation (AIM) Inventory which measures motivational aspect of the problem solving skills and lastly, the non-routinized test which measures the success in problem solving transfer. The data gathered were summarized, translated, and analyzed using the mean scores for both aspects of the problem solving skills and problem solving transfer. At 0.05 level of significance, the Pearson product moment r was used to test the significant correlation between the aspects of the problem solving skills and the success of problem solving transfer. Findings show that only the metacognitive knowledge predicts success in problem solving transfer and this is the only problem solving skills is significantly correlated to the success in problem solving transfer.

Keywords **-** Mathematics Education, metacognitive knowledge, predicts success, problem solving, descriptive- correlation design, Davao City, Philippines

INTRODUCTION

One of the greatest failures of Mathematics education is how the students deal with worded problems. At this point, students tend to get bored, avoid, dislike and unloved Mathematics as one of the disciplines taught in schools. Moreover, students perform poorly on Mathematics achievement especially in terms of problem solving. How can teachers and students learn ways in promoting problem solving transfer? Dealing with real word problems, developing creative thinking and acquiring the right attitude in Mathematics are great things the world of Mathematics must ever face in this twenty-first century. As what has been the mindset of every individual, Mathematics is always one of the difficult subjects ever experienced by students because teachers give less emphasis on the skills needed for the success of problem solving.

No Child Left Behind Act of 2001 (U.S. Department of Education, 2005) emphasizes that teachers are having more pressure to teach to the test rather than to work towards developing conceptual understanding on Mathematics. Hence, many students would rather acquire the important formulas that would only surpass the test requirement. However, when they encounter ill-structured problems, the difficulty arises and exhibited misconception on the task given (Mann, 2006).

These are the great dilemmas of Mathematics performance of the students nowadays. They are able to retain such information taught by the teacher, but cannot transfer it to real world problem (Mayer, 1998). These probably motivate school heads to push through the problem solving as the center piece of mathematics curriculum (Middleton et al., 2004).

The Trends in International Mathematics and Science Study (TIMSS) conveyed that Asian countries are on top rank in the field of Mathematics. These are the Singapore, Hong Kong, Chinese-Taipei, and Japan. Though Mathematics achievement is very high, problem solving skills were still inadequate to perform multi-step problem solving (TIMSS, 2007).

The result of National Achievement Test (NAT) here in Philippines for the school year 2005 – 2006 reflected a declining education based on the performance of the students in the country. The Grade 6 pupils average on overall achievement rate of only 54.5% while fourth-year high school students were worse with only

44.3%. Fortunately, fourth-year students perform best in Mathematics. However, only mastery of the skill was quite high and problem solving was not measured in National achievement Test.

Based on the report of National Education Testing Research Center (NETRC), Davao City ranked fourth (4th) from the bottom among 17 regions in the Philippines during 2006 National Achievement Test for Fourth-Year High School students. Hence, this cause an alarming situation that should seriously be addressed by the educators of the region and the country, as a whole.

With this distressing situations, the researcher was encouraged to conduct a study on the aspects that would probably give great contribution towards success in problem solving.

FRAMEWORK

Regardless of success in understanding how to stimulate routine problem solving using tried-and-true version of drill-and-practice method of instruction, the discipline continues to endeavor with how to promote non-routine problem solving.

This study is anchored on the idea that successful problem solving depends on three components – skill, meta-skill, and will – and that each of these components can be an influence by instruction, Mayer (1998). The meta-skill and will are the components that being use in the study. Metacognitive aspect and motivational aspect of Problem solving skill are the independent variable of the study. This is also supported by the theory of Constructivism which states that learners are to construct new ideas as an application on the concepts acquired by them. This is in a way of showing deeper understanding on the ideas learned, (Bruner, 1996). Constructivist learning improves students understanding into a different more realistic application in actual life of where they can demonstrate the thinking ability about the facts they have acquired.

Moreover, this is also supported by the Cognitive Flexibility Theory that focuses on the nature of learning in complex and ill-structured domains. Cognitive flexibility refers to the ability to restructure one's knowledge spontaneously in response to the increasing change in times. The theory is widely a concern with the transfer of knowledge and skills beyond their level of understanding into what field it may be. Another theory that supports the study is the humanistic theory set forth by Carl Rogers (Huitt, 2009). It states that a motivation might come from within an individual without any thought to an external reward. This

theory exemplifies the intrinsic motivation, a cognitive approach to motivation that necessitates students to think through the consequences of their actions and base their decisions on the expected outcome of those decisions. Lastly, the Behaviorist theory set forth by B.F Skinner (1963) which suggests as punishment and reward system as a motivational tool that encourage students to perform well in the task. In connection to the problem solving, students might work hard for it in order to obtain positive feedback and reward on it.

With these theories as benchmark, it is conceptualized that the success in problem solving transfer is dependent on the metacognitive and motivational aspect of problem solving skills.

OBJECTIVES OF THE STUDY

The objective of the study is to determine the influence of the problem solving skills such as metacognitive aspect containing knowledge and regulation in particular and motivational aspects containing the intrinsic and extrinsic motivation towards the success of the problem solving transfer. In particular it aims to determine (1) the level of the problem solving skills of students in terms of their metacognitive and motivational aspects, (2) the mean score of the students in problem solving transfer, (3) the predictor of success in problem solving transfer, (4) relationship of metacognitive aspect of the problem solving skills and success in problem solving transfer, (5) relationship of motivational aspect of problem solving skills and success in problem solving transfer.

METHODOLOGY

The study used the descriptive/quantitative correlational method. Correlations were computed between problem solving skills and problem solving transfer.

The study was conducted at Davao Central College, Philippines of S.Y. 2011-2012. The respondents of the study were the three sections such as Faith (90%), Hope (88%) and Love (66%) of Fourth-year high school students.

The instrument used in this study are the 52-item Metacognitive Awareness Inventory (Schraw & Dennison, 1994) of which the researcher has adopted. The test is composed of two parts, namely; metacognitive knowledge and metacognitive regulation. The Academic Intrinsic Motivation (AIM) was adopted from the study of Shia (1998) on her study, Academic Intrinsic and Extrinsic Motivation and Metacognition. This inventory is divided into two categories of

motivation; Intrinsic and Extrinsic motivation. These two adopted instruments are modified by the researcher to which fits the students in mathematics. Both instruments require respondents to rate each item on a 5-point scale ranging from strongly disagree (1) to strongly agree (5). Another instrument used was the 25-item "multiple choice" type of test from Nevara, 2009 in her textbook entitled Advanced Algebra with Trigonometry and Statistics. This measures the students' success in problem solving transfer. This test instrument encompasses the real life problems on selected topics in Fourth-Year Mathematics. This test has a reliability $\alpha = 0.85$. This means that the instrument passes the reliability test.

The conduct of the study was done by seeking permission first to head offices of the school before administering the instruments to the fourth-year students and gathered it after done on the first session. The second session was allotted for the conduct of the problem solving transfer test to the same students. Retrieval of the test was done, and the results were treated through the use of appropriate statistical tools.

RESULTS AND DISCUSSION

The problem solving skills in this study is measured through metacognitive and motivational aspects. Under metacognition, there are to indicators and these are metacognitive knowledge and metacognitive regulation. On the other hand, the motivational aspect also has two indicators and these are intrinsic motivation and extrinsic motivation.

The Level of the Problem Solving Skills in terms of the Metacognitive Aspect

Table 1. Level of the problem solving skills of students in terms of the Metacognitive aspect

Metacognitive Aspect of Problem Solving Skills	Mean	Descriptive equivalent
1. Metacognitive Knowledge	3.78	High
2. Metacognitive regulation	3.74	High
Overall	**3.76**	**High**

Data shows that there is a high level of manifestation on the metacognitive aspect both in knowledge (3.78) and regulation (3.74). This would mean that metacognitive aspect of the problem solving skill is high (3.76) also. This implies

that students are highly developed in the knowledge of cognition in determining appropriate skills and strategies that work best for the learner and for knowing how and when to use the chosen skills and strategies. On the other hand, the respondents also developed high regulation of cognition in controlling one's thinking and learning that includes planning, monitoring comprehension and evaluation. This is consistent with the idea that metacognitively aware students are more strategic that perform better than unaware learners. The knowledge about cognition and regulation are essential, and this knowledge allows individuals to plan, sequence, and monitor their learning in a way that directly improves their performance in non-routinize problems.

Level of Problem Solving Skills in terms of Motivational Aspect

Table 2. Level of problem solving skills of students in terms of Motivational Aspects

Motivational aspect of Problem Solving Skills		**Mean**	**Descriptive equivalent**
1.	Intrinsic Motivation	3.68	High
2.	Extrinsic Motivation	3.53	High
	Overall	**3.61**	**High**

The motivational aspect of problem solving skills is high (3.61) generated from the intrinsic motivation as high (3.68) and extrinsic motivation as high (3.53) as well. This result indicates that students manifest awareness on the motivational aspect of problem solving skills towards mathematics. This would imply that students who are intrinsically motivated developed mastery of goals and the need for achievement. On the other hand, students who are extrinsically motivated cultivated the factors such as authority expectations (family and teachers), peer acceptance, power motivations and fear of failure. Motivation is a force within the educational system to encourage students learning and understanding and thus dictates the students' behavior due to either external or internal factors.

The Summary on Problem Solving skills

Table 3. Summary on problem solving skills

Aspects of Problem solving Skills		Mean	Descriptive equivalent
1.	Metacognitive	3.76	High
2.	Motivation	3.61	High
	Overall	**3.67**	**High**

Problem solving skills reflects 3.67 mean score or high manifestation. This is due to the result obtained in its aspects namely; metacognition (3.76) and motivation (3.61) of which both are high in awareness. This implies that students are able to develop and explore the problem, extend solutions, process and develop self-reflection. On the other hand, metacognition and motivation are two of the aspects and skills necessary to a successful problem solver (Bruner, 1996). Likewise, students are highly equipped with metacognition and motivation in Mathematics. It emphasizes that organizing thoughts in such material, checking comprehension regularly, analyzing the usefulness of strategies differentiating learning strategies considering intellectual strengths and weaknesses and setting and meeting goals are demonstrated by the students. Moreover, the respondents are also motivated to set high goals for themselves. Students spend time for the things that interest them, demonstrate abilities in the classroom, and prefer to obtain good grades for the acceptance of others.

The Level of Success in Problem Solving Transfer

Table 4. Level of success in problem solving transfer

Problem Solving Transfer	Mean	Descriptive Equivalent	Interpretation/level
Fourth year Students	15.70	Very satisfactory	Denoted a high level of success

The mean score of the success in problem solving transfer is 15.70 with a descriptive equivalent of very satisfactory. This would mean that the students have a high level of success in the problem solving transfer. This supports the theory of Cognitive Flexibility (Spiro, Viltovitch and Coulson, 1990) that an individual may transfer the mastered skill in an ill-structured type of domain if

he is flexible in cognition. Thus, this implies that the students can construct new version of understanding highly in solving real life problems.

The Prediction of Success in Problem Solving Transfer

Table 5. Model Summary: The Prediction of Success in Problem Solving Transfer

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	14.77	2.782		5.313	0.00
	Metacognitive Aspect	1.558	.767	.216	2.059	0.42
	Academic Motivation	-1.370	.776	-.185	-1.764	.080

This shows that the metacognitive knowledge predicts the dependent variable which in problem solving transfer as reflected in the model shown in table 4. Academic motivation is not significant. The predicted success in problem solving transfer (Y) is approximately equal to 14.779 plus 1.558 of the metacognitive knowledge (X), that is:

$$Y = 14.779 + 1.558X.$$

The aspect of problem solving skills that predicts the success in problem solving transfer was the metacognitive awareness and metacognitive knowledge in particular. The model emphasized that as the metacognitive knowledge increases, problem solving transfer also increases. Furthermore, the unit and a half increase of metacognitive knowledge correspond to the increase of success in problem solving transfer.

The Relationship between the Aspects of Problem Solving Skills and Success in Problem Solving Transfer

The computed r-value for the correlation between metacognitive aspect of problem solving skills and problem solving transfer is 0.120 with its corresponding indicators knowledge and regulation as .186 and .041 respectively.

Table 6. Relationship between problem solving skills and problem solving transfer

Aspects of Problem Solving Skills	r - values	P-value	Decision on H_o
Knowledge	.186*	.040	Rejected

Note: Significant (Sig) if p<0.05

This means that the variance of success in problem solving transfer of the students could not be explained by the variance of the metacognitive regulation for its p-value 0.653 which is greater than the level of significance. However, only the small variance of success in problem solving transfer could be influenced by metacognitive knowledge in Mathematics contributes to the success in academic learning domains for its p-value = .040 is less than the level of significance. Hence, the null hypothesis that there is no significant relationship on the metacognitive aspect of the problem solving skills and success in problem solving transfer is not rejected. Therefore, there is no significant relationship on the metacognitive aspect of the problem solving skills and success in problem solving transfer. The result only implies that there is a need to consider how metacognitive abilities are acquired and develop, how knowledge could be used to help improve the performance with learning difficulties and how it relates to self-evaluation processes (Reeve & Brown, 1985). Somehow, on the aspect of metacognitive knowledge, students have acquired the skills and strategies that work best in the and even how to use the content and skills in solving real life problems.

On the other hand, data also show that the correlation between the motivational aspect of the problem solving skills and the success in problem solving transfer was 0.120 or not significant, 0.033 or not significant between intrinsic motivation and success in problem solving transfer, 0.073 or not significant between extrinsic motivation and success in problem solving transfer. This means that motivational aspect of the problem solving skills did not significantly relate to a very satisfactory level of problem solving transfer for its p-values of .424 (motivational aspect), .187 (intrinsic motivation) and .717 (extrinsic motivation) are greater than the level of significance. Thus, the null hypothesis that there is no significant relationship between motivational aspect of the problem solving skills and success in problem solving transfer was accepted. The findings of this study are consistent with the idea that extrinsic motivation across grade level proved negatively correlated with the academic outcomes (Lepper et al., 2005).Based on the result, it is not always true that when students are intrinsically motivated with

appreciation and enjoy the learning process on mathematics will tend to have focus on learning such as the mastery needed on mathematical concepts.

Among all indicators of the problem solving skills, only the metacognitive knowledge is significantly related to the success in problem solving transfer. Metacognitive knowledge refers to the knowledge of cognitive processes and product such as what a student knows about his cognition, how to use the strategies and procedure, and why or when to use a particular strategy. Hence, this implies that at the very start, knowledge of skills and strategies is significantly correlated to their success in problem solving transfer. This is supported by the predictability result of the study as mentioned earlier. Activities concerning control of students' thinking and learning as planning, monitoring comprehension and evaluation were observed to be not significantly correlated with students' success in problem solving transfer. It was also on the variables excluded as the predictor of the said success.

To sum it up, metacognitive skill acquisition is likely to accelerate students comprehension, understanding, mastery and reasoning skill necessary for problem solving transfer (Pesut &Herman, 1992), but, only to those who consistently create rules, picture out the conceptual problem, identify and make rules in describing the problem on it which is done simpler and easier without taking complex ways on solving problems.

CONCLUSIONS

Based on the findings, the following conclusions were drawn. The level of metacognition and motivation of students in the problem solving skills are high. Students' success in problem solving transfer was very satisfactory. Metacognitive knowledge predicts success in problem solving transfer. The metacognitive aspect of problem solving skills does not relate to the success in problem solving transfer. The motivational aspect of problem solving skills does not relate to the problem solving transfer.

LITERATURE CITED

Bruner, J. S. (1966). *Toward a theory of instruction* (Vol. 59). Harvard University Press.

Mann, E. L. (2006). *Mathematical creativity and school mathematics: Indicators of mathematical creativity in middle school students* (Doctoral dissertation, University of Connecticut).

Mayer, R. E. (1998). Cognitive, metacognitive, and motivational aspects of problem solving. *Instructional science*, *26*(1-2), 49-63.

Huitt, W. (2009). Humanism and open education. *Educational psychology interactive*.

Skinner, B. F. (1963). Operant behavior. *American Psychologist*, *18*(8), 503.

Middleton, J. A., Heid, M. K., Reys, R., Gutstein, E., Dougherty, B., D'Ambrosio, B. & Hala, M. (2004). An agenda for research action in mathematics education: Beginning the discussion. *Journal for Research in Mathematics Education*, 74-80.

Pesut, D. J., & Herman, J. (1992). Metacognitive skills in diagnostic reasoning: making the implicit explicit. *International Journal of Nursing Terminologies and Classifications*, *3*(4), 148-154.

Reeve, R. A., & Brown, A. L. (1985). Metacognition reconsidered: Implications for intervention research. *Journal of Abnormal Child Psychology*, *13*(3), 343-356.

Schraw, G., & Dennison, R. S. (1994). Assessing metacognitive awareness. *Contemporary educational psychology*, *19*(4), 460-475.

Shia, R. M. (2005). Academic Intrinsic and Extrinsic Motivation and Metacognition. Assessing Academic Intrinsic Motivation: A look at Student Goals and Personal Strategy. Wheeling Jesuit University. Retrieved on October 11, 2014 from http://www.cet.edu/pdf/motivation.pdf.

Trends in International Mathematics and Science Study (TIMSS) (2007). No Child Left Behind. Retrieved on October 11, 2014 from http://timssandpirls.bc.edu/isc/publications.html