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Are the dimensions of metacognitive awareness differing in prediction of mathematics and geometry achievement?

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Abstract

In this study, it is aimed to determine whether there is a differentation of metacognitive awareness strategies in prediction of high school students's mathematics and geometry course achievements. Data were obtained from 213 high school students and it is used to stepwise regression analyze technique to analyze the data. It is seen from the result that declarative knowledge of high school students is an significant predictor of mathematics course achievement ($p<.05$). Besides, it is found that the evaluation and procedural knowledge of metacognitive awareness strategies are significant predictors of geometry course achievement.

Keywords: Mathematics achievement; geometry achievement; metacognitive awareness

1. Introduction

Mathematics has a comprehensive structure in terms of its content. In teaching this comprehensive structure, it needs different strategies as well. National Council of Teachers of Mathematics (NCTM) states that the content of mathematics in schools focus on data analysis, probability, algebra, geometry, and measurement that can then be applied in everyday life (NCTM, 2000). It is expected from the teachers to focus on the content, to know algorithms for multi-digit computation with whole numbers, to specialize in teaching mathematics, to be aware of a deep understanding of why the standard algorithms work and to have knowledge of alternative algorithms (Mcleod, & Huinker, 2007). As an active and structural process in learning mathematics, the students need to undertake control and agency over his/her own learning and problem solving activities (De Corte, Verschaffel, & Op't Eynde, 2000). Garofalo and Lester (1985) indicated that mathematical strategy knowledge is a knowledge of algorithms and heuristics, but also a knowledge of mathematical strategy includes a person's awareness of strategies to aid in comprehending problem statements, organizing information or data, planning solution attempts, executing plans, and checking results.

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Mathematical task knowledge includes someone's beliefs about mathematics subjects besides the nature of matmehatics duty. These information at the same time contains an awareness of the effects of task features like content, context, structure and syntax on task difficulty (Garofalo, & Lester, 1985; Goldin & McClintock, 1984).

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Garofalo and Lester (1985) stated that the activities which take place in the performance of duty which is about mathematics consisted of four category called orientation, organization, execution, and verification.

Because the content of mathematics is comprehensive, this content parts lessons like general mathematics and geomety and also different instruction strategies and models are used. (Senk, 1989; Swafford, Jones, & Thornton, 1997;Van Hiele, 1986). For the students, to learn mathematics and geometry content knowledge and for their permanent, it supposed to be developed metacognitive learning strategies which is about how they learned and metacognitive awareness strategies which is about how they use these metacognitive strategies (Garofalo, & Lester, 1985; Goldin & McClintock, 1984; Gourgey, 1998; Hartman & Sternberg, 1993; Schraw, 1998; Wenden, 1998).

Metacognition is described someone's awareness and control of his learnings (Baker & Brown, 1984; Flavell, 1979). Brown (1978) defined the metacognition as planning the learning, problem solving, developing an awareness about thinking process and organizing this thinking process. As a functional description, metacognition is someone's awareness about how he learned, reaching an aim and how to use the knowledge when he is not understand and aware of this, the ability of judgement in the cognitive demand in special duty, the strategy knowledge related with the aims and the evaluation of someone's both in the process and after the process (Gourgey, 1998).

Metacognition is knowledge and regulatory skills to control individual's own cognition. That's why metacognition is a general emotion in categorizing a number of components. All of these components are intercorrelated (Schraw & Dennison, 1994).

Flavell (1979) divides metacognitive knowledge three categories: (a) self-knowledge (knowledge of person variables), (b) task knowledge (task variables) and (c) strategic knowledge (strategy variables). Boekaerts (1997) refers to metacognitive knowledge as aspects of student's theory of mind, theory of self, theory of learning and learning environments. Metacognitive knowledge enables the students to understand better, follow or evaluate the concept and procedural knowledge is related to a domain.

According to Hartman (1998) metacognition is important because it effects acquisition, comprehension, retention and implementation of learnings. It also effects learning efficiency, critical thinking , and problem solving as well. Metacognitive awareness allows self-regulation on the control or thought and learning process and outcomes. The knowledge of cognition refers to what the individual generally knows about cognition or one's own cognition. It is stated that metacognitive awareness has at least three types, such as declarative, procedural, and conditional knowledge) (Brown, 1987; Jacobs & Paris, 1987; Schraw & Moshman, 1995). Ridley, Schutz, Glanz, and Weinstein (1992) defined the metacognitive awareness as the process of using reflective thinking on developing one's awareness about his own personal, task, and strategy knowledge in a context. Hartman and Sternberg (1993) indicated that there are four ways to improve metacognitive awareness in classroom structure. They include promoting general awareness of the importance of metacognition, improving knowledge of cognition, improving regulation of cognition, and fostering environments that promote metacognitive awareness.

Because mathematics and geometry have different content, the metacognitive awareness of students can change in these lessons. Therefore, the problem of this study is to determine whether there is a differentation of metacognitive awareness strategies or not in predicting mathematics and geomety achievement.

2. Methodology

In this study, a quantitative method was used. The quantitative data helped to determine whether significant associations exist between independent variables and dependent variables or not. Metacognitive awareness was the independent variable for the study, while mathematics and geometry achievement were the dependent variables. In this study, to what extent metacognitive awareness served as predictors of mathematics and geometry achievement were analyzed.

2.1. Participants

Participants of this study were 108 (50,7%) males and 105 (49,3%) females who attend mathematics and geometry lessons in Konya Anatolian High School at 10th and 11th levels.

2.2. Research Instruments

2.2.1. Metacognitive Awareness Inventory (MAI)

Metacognitive Awareness Inventory (MAI) was developed by Schraw and Dennison (1994) has been adapted to Turkish by Akın, Abacı and Çetin (2007). A total of 52 items were accompanied by a 5-point response scale ranging from "strongly agree" to "strongly disagree". MAI consists several subscales assessing knowledge of cognition (declarative knowledge, procedural knowledge, conditional knowledge) and regulation of knowledge (planning, monitoring, evaluation, debugging strategies and information management strategies). The internal consistency of the entire inventory was .95. The item-total correlations ranged from .35 to .65 and test-retest reliability coefficant was .95.

Mathematics and geometry GPAs' from end-of-the-year were obtained from official student records. Students responded to a set of brief demographic questions asking their gender in addition to the MAI.

2.3. Data Analysis

In this study, multiple linear regression analysis was used. In multiple linear regression analysis, the relationship between the predictor variables, students' mathematics and geometry achievements, and the dependent variables, metacognitive awareness (declarative knowledge, procedural knowledge, conditional knowledge, planning, monitoring, evaluation, debugging strategies and information management strategies), was tested. Data were analyzed using SPSS 15.0 (Statistical Package for Social Sciences) software.

3. Findings

A stepwise regression analysis method was used to determine whether metacognitive awareness is predictor of high school students' mathematics achievement or not. Findings from stepwise regression analysis are summarized in Table 1. According to the findings of the study, declarative knowledge are significant predictors of college students' mathematics achievement ($p<.05$). 2.3% of the variance in mathematics achievement was explained by declarative awareness one of the subscales of metacognitive awareness.

Table 1. Model summary for stepwise regresion analysis of mathematics course achievement

Model [a]	R	R Square	Adj. R Square	Std. Err.	R Square Change	F Change	Df_1	Df_2	Sig. F Change
1	.165 [b]	.027	.023	17.13	.027	5.91	1	211	.016

[a]: Dependent variable: Mathematics achievement.
[b]: Predictors: (Constant), declarative knowledge

A stepwise regression analysis method was used to determine whether metacognitive awareness is predictor of high students' geometry achievement. Findings from stepwise regression analysis are summarized in Table 2. According to the findings of the study, evaluation and procedural knowledge are significant predictors of high school students' geometry achievement ($p<.05$). 4.7% of the variance in geometry achievement was explained by evaluation one of the subscales of metacognitive awareness, while 7.6% of its variance was explained by evaluation and precedural knowledges.

Table 2. Model summary for stepwise regresion analysis of geometry course achievement

Model [a]	R	R Square	Adj. R Square	Std. Err.	R Square Change	F Change	Df_1	Df_2	Sig. F Change
1	.227 [b]	.052	.047	13.86	.052	11.46	1	211	.001
2	.290 [c]	.084	.076	13.65	.033	7.63	1	210	.007

[a]: Dependent variable: Geometry achievement.

[b]: Predictors: (Constant), evaluation.

[c]: Predictors: (Constant), evaluation, procedural knowledge

4. Discussion

In the study, it has found that declarative metacognitive awareness strategy is an significant predictor of mathematics achievement. Swanson's (1990) research findings which determines that declarative knowledge of cognition facilitates regulation of problem solving among students support this study findings. Because, problem solving is one of the most important phases in mathematics knowledge (Polya, 1957). The students must know that what the facts effect their performance are and what they must know to be succesfull in mathematics. It is possible with the declarative knowledge which is one of the strategies of metacognitive awareness strategies. According to Schraw (1998) declarative knowledge is a strategy includes the knowledge about the facts that effect learning performance.

It has found that high school students' evaluation and procedural knowledge of metacognitive awareness strategies are two significant predictors of geometry achievement. The evaluation which is one of the metacognitive awareness strategies is predictor of geometry ahievement. It is related with the convertion of feedbacks to the improwing performance. It is also related with the student's attention of feedbacks on how to progress on tasks which is neccessary for success in lessons (Gourgey, 1998). Procedural knowledge of awareness atrategy is also a predictor of geometry achievement. It is related with procedural knowledge which is neccessary in the process of controlling and regulation of learning activities (Schraw & Moshman, 1995). Pressley, Borkowski, and Schneider (1987) indicate that the performance duty of individuals who have high procedural knowledge is more automatically. They have more strategy repertory and they use sequence strategies effectively. This also supports the findings of the study.

According to the results in the study, following recommendations are taken place:

1. The students' efficacy related to their ability, cognitive aims and learning duties must be developed to be succesfull in mathematics.

2. Learning outcomes and efficiency of the students must be evaluated to be succesfull in geometry. Besides this, for geometry achievement, problem solving strategies are taught and continually reinforced in the extra math period.

References

Akın, A., Abacı, R., & Çetin, B. (2007). The validity and reliability study of the Turkish version of the Metacognitive Awareness Inventory. *Educational Science: Theory & Practice,* 7(2), 655-680.

Baker, L. and Brown, A. L. (1984). Metacognitive skills and reading. In P.D. Pearson, R. Barr, J.L. Kamil and P. Rosenthal, eds., Handbook of reading research. New York: Longman Press.

Battista, M. T. (1990). Spatial visualisation and gender differences in high school geometry. *Journal for Research in Mathematics Education,* 21, 47-60.

Boekaerts,M. (1997). Self-regulated learning:Anewconcept embraced by researchers, policymakers, educators, teachers and students. *Learning and Instruction,* 7(2), 161–186.

Brown, A. L. (1978). Knowing when, where and how to remember: A Problem of metacognition. In R. Galaser (Ed.), *Advences in instructional psychology* (pp. 225-223), Hillsdale, NJ: Lawrence Erlbaum Associates,Inc.

Brown, A. (1987). Metacognition, executive control, self-regulation, and other more mysterious mechanisms. In F.Weinert & R. Kluwe (Eds.), *Metacognition, motivation, and understanding* (pp. 65–116). Hillsdale, NJ: Erlbaum.

De Corte, E., Verschaffel, L., & Op't Eynde, P. (2000). Self-regulation. A characteristic and a goal of mathematics education. In M. Boekaerts, P. Pnitrich, & M. Zeider (Eds.), *Handbook of self-regulation* (pp. 687–726). USA: Academic press.
Flavell, J. (1979). Metacognition and cognitive monitoring. *American Psychologist,* 34, 906–911.
Garofalo, J., & Lester, F. K. (1985). Metacognition, cognitive monitoring, and mathematical performance. *Journal for Research in Mathematics Education,* 16(3), 163-176.
Goldin, G. A., & McClintock, C. E. (1984). *Task variables in mathematical problem solving*. Philadelphia: Franklin Institute Press.
Gorgorio, N.(1998). Exploring the functionality of visual and non-visual strategies in solving rotation problems'. *Educational Studies in Mathematics,* 35, 207-231.
Gourgey, A. F. (1998). Metacognition in basic skills instruction. *Instructional Science,* 26(1-2), 81-96.
Hartman, H. J. (1998). Metacognition in teaching and learning: An introduction. *Instructional Science,* 26, 1–3.
Hartman, H. H., & Sternberg, R. J. (1993). A broad BACEIS for improving thinking. *Instructional Science,* 21, 401–425.
Jacobs, J. E., & Paris, S. G. (1987). Children's metacognition about reading: Issues in definition, measurement, and instruction. *Educational Psychologist,* 22, 255–278.
Mcleod, K., & Huinker, D. (2007). University of Wisconsin-Milwaukee mathematics focus courses: Mathematics content for elementary and middle grades teachers. *International Journal of Mathematical Education in Science and Technology,* 38(7), 949–962.
National Council of Teachers of Mathematics. (2000). *Principles and standards for school mathematics*. Reston, VA: Author.
Polya, G. (1957). *How to solve it?* Princeton, NJ: Princeton University Press.
Pressley, M., Borkowski, J. G., & Schneider, W. (1987). Cognitive strategies: Good strategy users coordinate metacognition and knowledge. In R. Vasta, & G.Whitehurst (Eds.), *Annals of Child Development* (pp. 890-129). Greenwich, CT: JAI Press.
Ridley, D. S., Schutz, P. A., Glanz, R. S., & Weinstein, C. E. (1992). Self-regulated learning: The interactive influence of metacognitive awareness and goal-setting. *The Journal of Experimental Education,* 60(4), 293-306.
Schraw, G. (1998). Promoting general metacognitive awareness. *Instructional Science,* 26*,* 113–125.
Schraw, G., & Dennison, R. S. (1994). Assessing metacognitive awareness. *Contemporary Educational Psychology,* 19, 460–475.
Schraw,G., & Moshman, D. (1995). Metacognitive theories. *Educational Psychological Review,* 7*,* 351–371.
Swanson, H. L. (1990). Influence of metacognitive knowledge and aptitude on problem solving. *Journal of Educational Psychology,* 82*,* 306–314.
Swafford, O. J., Jones, G. A., & Thornton, C. A. (1997). Increased knowledge in geometry and instructional practice. *Journal for Research in Mathematics Education,* 28(4), 467-483.
Van Hiele, P. M. (1986). *Structure and insight: A theory of mathematics education.* New York: Academic Press.
Wenden, A. L (1991). *Leamer strategies for leamer autonomy.* London: Prentice Hall.