Exploring 8th Graders' Metacognition and its Relationship with Mathematical Academic Achievement

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Abstract

Present study was intended to measure the metacognition of Grade 8 students and to find its relationship with their mathematical achievement. The study was quantitative by nature and correlational method was used to explore relationship between students' metacognition and mathematical achievement. A standardized tool Junior Metacognitive Inventory (Jr. MAI) was used to explore metacognition of 90 students of Grade 8 in a public school. A pilot study helped to find the validity of the tool in Pakistani context. Data was collected through getting mathematics marks of the students in their last school examination held according to the format given by the Punjab Examination Commission. Data collected was analyzed through descriptive statistics and relation was studied by Pearson's correlation coefficient. Results showed that a positive correlation exists between metacognition of the students and academic achievement in Mathematics of Grade 8 students. Teachers' trainers are strongly recommended to introduce metacognitive strategies among teachers and experimental studies are being suggested to explore effective strategies to develop metacognition among students to enhance Mathematical achievement.

> ***Keywords:*** metacognition, junior metacognitive inventory, mathematics achievement

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Introduction

Metacognition has been acknowledged as one of the strong predictor to bring about high level learning tasks for few years (Dignath & Buttner, 2008; Van der Stel & Veenman, 2010).

Generally metacognition is considered as a combination of general skills instead of specific. These skills are different from general intelligence and this ability of a student offers support to overcome the insufficiency of intelligence and former knowledge related to any problem solving situation (Schraw, 1998).

Metacognition initially coined by Flavell (1979) as self-awareness of an individual about his own thinking process and his ability to control or regulate his cognition (Flavell, 1979; Hacker & Dunlosky, 2003; Jager, Jensen, & Reezigt, 2005). In simple words metacognition means thinking about an individual's own thinking process. Flavell's model was based on four constituents: metacognitive knowledge, cognitive goals, cognitive strategies and metacognitive experiences.

Flavell explained metacognitive knowledge as a blend of person, task and strategy. He believed that cognitive strategies are used to accomplish cognitive/thinking goals through some cognitive experiences. Flavell also declared that the higher extent of effective interaction of above mentioned components leads to make sure the attainment of the complex learning tasks.

Consequent researches helped to present an explicit and comprehensive detail of the constituents of metacognition. Brown (1987) described knowledge of cognition and regulation of cognition as two major components of the construct metacognition.

Knowledge of cognition is further divided into three types of knowledge as declarative knowledge, procedural knowledge and conditional knowledge. Declarative knowledge stands for the knowledge of one's own knowledge being a learner while procedural knowledge is meant for the awareness of variety of approaches and techniques for effective learning process (Cross & Paris, 1988; Schraw, Crippen & Hartley, 2006). Whereas the expertise of using both declarative and procedural knowledge appropriately is termed as conditional knowledge (Schraw et al., 2006).

Control or regulation of cognition deals with the regulatory management of one's own cognition. Many researchers agreed on Planning, monitoring, management of strategies, evaluation and debugging as different stages of metacognitive regulation. (Brown, 1987; Cross & Paris, 1988; Schraw & Moshman, 1995; Whitebread et al., 2009). Metacognitive monitoring is a process to regulate all mental

processes to get control on one's own learning behavior and ultimately positively effect on better attainment of the tasks. Metacognitive skill may contribute in 40% progression consequences in a variety of learning activities (Veenman, 2008). In short, metacognitive knowledge and regulation are indicators of the presence of metacognition.

Metacognition measurement has been a provocative issue for researchers and teachers of all the times. The arguments are based on measuring metacognition by using simple and accurate different tools (Schellings, Hout-Wolters, & B. H. A. M. 2011).

Research literature about metacognition provides the detail of variety of instruments used to measure metacognition by numerous researchers but all those methods have their own strengths and weaknesses. Self-report inventories, questionnaires, think aloud, interviews, observational techniques and diagnostic tests are included in the instruments used so far.

One of the earliest methods used to measure metacognition was interview by Myers and Paris in 1978. That interview was structured on the basic components of metacognition described by Flavell & Wellman (1977). In later years an improved structured interview was also used to measure metacognition of young children before and after intervention (Paris & Jacob, 1984).

Think-aloud is considered as one of the effective method to measure metacognition. In this method information are collected during verbalization of thought processing of an individual and then transcribed to study the results (Veenman et al., 2005). As this method completely depends on the students' verbal expressions and every student cannot be good at voicing his thought process. This is a great concern related to the reliability of Think-aloud method (Whitebread et al., 2009).

Metacognitive Awareness Inventory (MAI) by Schraw & Dennison (1994) is frequently used and considered as well validated tool to measure metacognition in adults. MAI is a 52 items based comprehensive inventory, comprised of questions related to components and sub-components of metacognition like knowledge (declarative, procedural & conditional) and regulation (planning, monitoring & evaluation). Junior Metacognitive Inventory (Jr. MAI) (Sperling, Howard, Miller & Murphy, 2002) is a modified form of MAI (Schraw & Dennison, 1994), to measure metacognition of children of two different age groups.

Metacognition Assessment and Academic Achievement

Substantial research has validated the significance of metacognition in the academic achievement of the students. Generally, students

possessing higher level of metacognition have greater ability to monitor and regulate their cognitive abilities. Which enable them to perform better academically also (Pintrich, 2002). A number of studies considered higher metacognition as a strong predictor of academic achievement also (Dunning, Johnson, Ehrlinger & Kruger, 2003; Sperling, Howard, Staley & DuBois, 2004; Young & Fry, 2008; Kocak & Bayaci, 2010).

Two meta-analysis reports are considered as dynamic support to evident the influence of metacognition on students' academic achievement. Wang, Haertel & Walberg (1990) declared metacognition as most effective factor for the improvement of learning and academic achievements. They reviewed more than 100 articles and studied the relationship between 30 variables and found strongest association between academic achievement and metacognition of the students. While Dignath, Buettner & Langfeldt (2008), carried out a meta-review of experimental studies to explore most dominant factor in self-regulated learning. They reported metacognition centered intervention as most effective one.

The research history of mathematics in the context of metacognition is as old as metacognition itself. Shortly after the introduction of metacognition, Mathematical problem solving researchers considered metacognition best fitting to their domain (Schneider & Artelt, 2010). In early studies Lester & Garofalo (1982) considered metacognition as one of the important factor to promote Mathematical problem solving among students. He also predicted the vital role of metacognition knowledge and regulation in Mathematical problem solving process. In later years, Verschaffel et al. (1999) emphasized on the importance of metacognition through Mathematical problem solving processes especially in the beginning and final evaluative stage.

The positive correlation between metacognition and mathematical achievement is evident from previous researches. Everson, Tobias & Laitusis (1997) studied relationship between metacognitive knowledge and academic achievement in both mathematics and verbal skills of the students. The results of the study supported positive correlation between Mathematics and metacognition. The findings of Everson and Tobias (1998) also showed significant correlation between Mathematics achievement and metacognition monitoring. But the conclusions of a study conducted by Sperling et al. (2004) contradict with previous studies. Sperling et al (2004) administered Metacognitive Awareness Inventory for measuring metacognition of college students and couldn't find any relation between academic achievement and MAI scores of the students. Rather concluded negative correlation between MAI scores and

SAT scores of Mathematics. Young and Fry (2008) also used MAI to explore metacognition of college students. Cumulative GPA and MAI scores were found positively correlated. A finding of another research by Smith (2013) shows no correlation between mathematical performance in differential equations and metacognition. He further concluded that higher level of metacognition never provides assurance of good academic result too in Mathematics.

Metacognition is comparatively a new construct in Pakistan but its significant role is acknowledged throughout the World in attaining both higher learning tasks and developing problem solving skills. Present study would help to recognize the worth of metacognition during teaching-learning process. Positive association between metacognition and Mathematical academic achievement would lead the teachers to focus in developing metacognition among the students to promote better understanding of Mathematical concepts.

The study would also help teachers' trainers to plan and introduce metacognitive based training to equip the teachers with modern strategies to improve Mathematical results at elementary level. It may also motivate teachers and researchers to conduct experimental studies to explore effective strategies to develop metacognition among students.

The objectives of the present study were:
1. Exploration of the metacognition of Grade 8 students.
2. To examine the relationship between metacognition and academic achievement of Grade 8 students.

Methodology

The study was quantitative by nature and correlational method was used to study the relationship between Grade 8 students' metacognition and mathematical achievement.

All Grade 8 students studying in public schools in Lahore were population of the study. A public Girls high school in Lahore was selected through convenient sampling method. All 90students of that school were taken as sample of the present study.

Junior Metacognitive Inventory Jr. MAI by Sperling et al. (2002) was used to measure metacognition of Grade 8 students. It is an amended form of Schraw and Dennison's metacognitive awareness inventory (1994), which is used to measure metacognition of adults. Junior Metacognitive Inventory Jr. MAI by Sperling et al. (2002), is recognized as a reliable instrument with Cronbach's alpha as .85 (Schwartz, Andersen, Hong, Howard & McGee, 2004). Inventory is comprised of 18 statements of 4-

likert scale from always (4) to never (1). Nine statements are about to measure knowledge of cognition and remaining 9 are about to assess regulation of cognition. After getting formal permission from Sperling, Jr. MAI was translated in students' innate language (Urdu) to facilitate public school students to understand the statements easily to respond.

Three language teachers reviewed translated version of the inventory. Suggested amendments were made accordingly. Urdu version of the inventory was administered in another public girls school for pilot study. That helped to improve the validity of Jr. MAI(Urdu version) in Pakistani context. Cronbach's alpha of the instrument was calculated as 0.93.

District Girls high school (sample)was preparing the students of Grade 8 according to the assessment format given by Punjab Examination Commission. Mathematical achievement scores of last school examination were collected from the school and tabulated the results. Junior Metacognitive Inventory Jr. MAI by Sperling et al. (2002) in Urdu version was administered to measure metacognition of Grade 8 students. Metacognition total scores (MAI total), knowledge of cognition (MAI Know.), regulation of cognition (MAI Reg.) and Mathematics marks were tabulated in a sheet for analysis.

Results and Discussion

Descriptive statistics were used to analyze data collected. Pearson correlation coefficient and regression were calculated to find the extent of the relation between students' MAI total, MAI Know. MAI Reg. and Mathematics marks. As four new students were enrolled after the achievement test conducted in the school which was recorded for analysis, consequently the data of 86 students was analyzed.

Table 1

Descriptive analysis of MAI total, MAI Know.*, MAI Reg. and Mathematics marks*

Variable	N	Mean	*S.D.*	Minimum	Maximum
Marks	81	55.93	15.271	17	89
MAI total	81	37.99	5.149	28	49
MAI Know.	81	20.72	3.005	14	26
MAI Reg.	81	17.27	2.622	13	23

Table 1 shows that the mean mathematics marks are 55.93, mean of MAI total is 37.99 out of total score 72, mean MAI Know. is 20.72 out of 36 score and mean MAI Reg. is 17.27 out of 36 score.

Table 2

Correlation between MAI Know., MAI Reg., Metacognition score (MAI total) and Mathematics marks

	Variable	Marks	MAI total	MAI Know.	MAI Reg.
1.	Marks	___			
2.	*MAI total*	.712**	___		
3.	*MAI Know.*	.716**	.926**	___	
4.	*MAI Reg.*	.576**	.902**	.673**	___

**. Correlation is significant at the 0.01 level (2-tailed).

Table 2 shows that the correlation coefficient between Metacognition Scores (MAI total) and Mathematics marks is0.712**, indications of high positive correlation between the variables. As 0.65 or higher values of correlation coefficient is considered as rationally precise for the explanation of different resolutions (Frankle & Wallen, 2009). Moreover table 2 shows strong positive correlation between, Mathematics marks and MAI know. with correlation coefficient 0.716**.

Also MAI total and MAI Reg. are strongly correlated with correlation coefficient 0.902**. Whereas MAI total and MAI know. Shows strong correlation with correlation coefficient 0.926**.But correlation coefficient between Mathematics marks and MAIReg. is 0.576**which supports moderate correlation between the variables. MAI know. and MAI Reg. are also strongly correlated with correlation coefficient of 0.673**.Correlation is significant at the 0.01 level (2-tailed).

Table 3

Regression analysis of MAI total and Mathematics marks

Variable	N	R	R^2	Beta	t	Sig.
MAI total	81				9.001	.000
		.712	.507	.712		
Mathematics Marks	81				2.697	.009

The value of R square (.507) shows 50% contribution of metacognition (MAI total) in students' academic achievement of Mathematics. It recommends that students' high metacognition would facilitate them to raise their mathematical academic achievement.
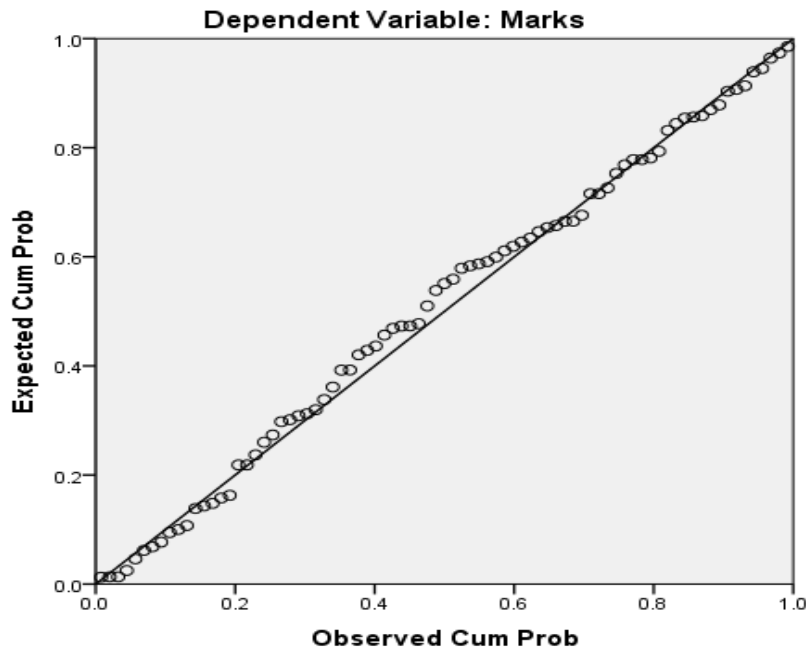

Figure 1 Normal p-p plot of regression standardized residuals

Normal p-p plot of standardized residuals of a linear regression model shows the close clustering of the points along sides of the sloping line, which is evident, that the residuals are normally distributed.

Current study was planned to examine the metacognition of 8th Graders and to study its relationship with academic achievement of Mathematics. Metacognition of Grade 8 students were measured by using Urdu version of Jr. MAI by Sperling et al., (2002). Two sub constructs of metacognition (knowledge of cognition and regulation of cognition) were also measured separately. Mean total metacognition, Knowledge of cognition and regulation of cognition of students were found to be on an average level. Moreover Knowledge of cognition among students of Grade 8 was found comparatively higherthan regulation of cognition.

A strong correlation was reported between Mathematics marks and metacognition of Grade 8 students. This supports to conclude that students possessing higher metacognition would also get higher marks in Mathematics. The results of present study are aligned with previous studies (Pintrich, 2002; Young & Fry, 2008; Kocak & Bayaci, 2010).

Furthermore, a significant strong association is also observed between Mathematics achievement and knowledge of cognition but moderate association with regulation of cognition. However significant positivecorrelation was found between both components of metacognition. Young & Fry (2008) studied relations between metacognition, its components and broad measures of academic achievement. A strong correlation of academic achievement was reported with both knowledge of cognition and regulation of cognition.

As metacognition is measured as a combination of two factors metacognitive knowledge and regulation, students' metacognitive knowledge enables them to become aware about their own weaknesses and strengths regarding their thinking process. Then students are more likely to reflect in a better way in their learning process (Pintrich, 2002).

Metacognitive knowledge and awareness motivates a student to expose their own hidden talents to perform even better (Kocak & Bayaci, 2010). Metacognitive knowledge and regulation can be considered as significant predictors of Mathematics achievement.

Schraw (1994) studied metacognitive knowledge and regulation thoroughly and concluded that metacognitive knowledge of adult students is more or less same but regulation of cognition differs from student to student. He endorsed that the progression of these two constructs of metacognition may not affect each other. Generally knowledge of cognition is likely to be developed first then regulation of cognition.

Schraw and Dennison (1994) used their renowned Metacognitive Awareness Inventory (MAI) to measure cognition of knowledge, regulation of cognition and their relation with test performance. Findings of their study supported the positive correlation between test achievement and knowledge of cognition but not with regulation of cognition.

As Mathematics is somewhat more to learn formulas and concepts, rather decision making related to when, where and exactly how proficiently to apply already learnt concepts (Schoenfeld, 2014). Metacognitive knowledge and self-awareness of an individual's abilities enables students to regulate executive thinking process. Ahigh level thoughtful processhelps beings to identify, organize and regulate their thinking processes. Outcomes of findings support to raise the metacognition of 8th Graders to enhance Mathematics achievement.

Conclusion and Recommendations

Results establish the significant positive relationship between metacognition and Mathematics marks of Grade 8 students of a public school. These results support all studies those consider metacognition as one of the strong predictor of academic achievement (Dunning et al., 2003; Kocak & Bayaci, 2010; Young & Fry, 2008).

As present study is conducted in a Pakistani public school, it shows the importance of metacognition of the students in this context to raise mathematics achievements at elementary level. It is only possible when Mathematics teachers will become familiar with this construct, its' importance and ways to develop metacognitive knowledge and regulation among students. Teachers' trainers are strongly recommended to introduce metacognitive strategies to Mathematics teachers to improve academic achievements of Mathematics. Further studies may explore relationship between metacognition and academic achievement of other subjects at different Grade levels even. Teachers' trainers should include this strategy in the curriculum. More experimental studies are desired to explore effective strategies to develop metacognition and regulation skills among students.

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