Self-Regulated Learning: A Motivational Approach for Learning Mathematics

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Abstract:

Self-regulated learning is identified as a fruitful learning strategy as evidenced from the increase in the number of researches in academic self-regulation since year 2000. Knowing to manage one's own learning is helpful in attaining the goals. This analysis of literature on self-regulated learning focuses on the factors that affect self-regulated learning and the students' learning outcomes from application of self-regulated learning. This paper identifies major categories of variables studied in relation to self-regulated learning, and summarizes the findings there from. Factors like cognitive strategy use, meta-cognition, self-efficacy and other motivational beliefs and some individual differences were considered. An inter relationship between self-efficacy and self-regulated learning is manifest. Mastery goal orientation favours self-regulated learning. Areas of language and mathematics education manifests more studies on self-regulated learning than other curricular areas. Findings from both the areas confirm that self-regulated learning results in enhanced achievement and desirable affective outcomes. How the self-regulated learning is linked to mathematics learning outcomes is specifically elaborated for facilitating future research and classroom practices especially in mathematics education context around this motivational construct.

Keywords: *Self-regulated learning, Motivational beliefs, Mathematics learning*

I. INTRODUCTION

Earlier research on students' learning and its' outcomes has given emphases to cognitive strategies, metacognition, motivation, task selection and engagement, and social supports in classrooms. Self-regulated learning (SRL), a cognitive motivational approach to learning, covers various aspects of academic learning, and discusses more holistic view of student acquisition of the skills, knowledge, and motivation (Paris & Paris, 2001). Self-regulated learning is a part of social cognitive theories. A great deal of research has been conducted on the topic of self-regulated learning, because it is found very helpful in attaining goals and improving performance in varied human acts.

Self-regulation is the ability to manage one's own energy states, emotions, behaviours and attention, in ways that are socially acceptable and help achieve positive goals, such as maintaining good relationships, learning and maintaining wellbeing. Self-regulated learners are learners who manage their learning, engage in more metacognitive monitoring and control, and are more intrinsically motivated (Zimmerman, 1990). SRL is ''an active, constructive process whereby learners set goals for their learning and then attempt to monitor, regulate, and control their cognition, motivation, and behaviour, guided and constrained by their goals and the contextual features in the environment'' (Pintrich, 2000). Self-regulated learners are distinctive in being meta-cognitively, motivationally and behaviourally active in one's own learning process and in achieving one's own goals (Eccles&Wigfield, 2002). SRL has interconnections with many factors, like self-efficacy, goal orientation, task value, strategy use and metacognition (Pintrich, 1999). Research suggest that self-regulated learning and performance are related (Zimmerman,1998; Pintrich, 1999). Accordingly numerous studies have been conducted to examine these relations.

II. NEED FOR THIS REVIEW

Self-regulation is viewed as the fourth 'R' of education as critical to student success as a firm foundation in reading, writing and arithmetic (The fourth R, 2014). This analysis of literature is important because no recent reviews of studies on self-regulated learning are available. This review reveals the growing importance of self-regulated learning researches and focuses on the factors that affect self-regulated learning and on the students' learning outcomes from application of self-regulated learning.

III. OBJECTIVES

This review is to study the researches on factors that have a bearing on self-regulatory skills in academic learning and to specifically explore the effect of such skills on mathematics related outcomes. Specifically this meta-analytic review is to answer the questions viz., what leaner and schools factors are associated with self-regulated learning, what factors will help enhance self-regulated learning and what impact self-regulated learning has specifically on mathematics related outcomes. In doing so, this study reveals the trends in researches on self-regulated learning during the last one and half decades.

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IV. SAMPLE

Thirty-five studies on self-regulated learning reported in journals spanning from1998 to 2016 obtained from Google search with key term self-regulated learning were reviewed in this study.

V. METHODS

Analysis of the sampled studies was done in terms of year of study, independent and dependent variables, level of education (primary, secondary, and tertiary or teacher education), design of study, sample size, tools/ techniques used in data collection and methods of analysis.

VI. RESULT AND DISCUSSION

The results had been grouped under two broad sections namely studies on self-regulated learning in general academics and interrelationship among self-regulated learning, self-efficacy and mathematics outcomes. Different headings were given on the basis of aim, variables considered and methodology followed in the study.

Studies on self-regulated learning in general academics

Studies on enhancing SRL and achievement

A number of experimental or case studies had been conducted in different levels of schooling with a view to improve SRL and thus to improve learning outcomes. In case of kindergarten students, creating classroom contexts that support young children's development of self-regulated learning helps the learners to develop self-regulated learning (Perry &VandeKamp, 2000). Use of metacognitive strategy among eleventh graders is affected by their goal orientation and the reward they got (McWhaw & Abrami, 2001). Use of metacognitive strategy is found affected also by students' achievement level (DiFrancesca, Nietfeld & Cao, 2016) and prior knowledge (Taub, Azevedo, Bouchet & Khosravifar, 2014).

It is possible to enhance students' self-regulatory judgments and math performance greatly through self-regulatory strategy training (Ramdass & Zimmerman, 2008).Also, significant effect was found for a learning mediation, text based learning associated with the elaboration of concept maps and training of self-regulated learning, in improving in-depth processing (Mih & Mih, 2011). Kostons, Gog and Paas (2012) have proved that training self-assessment and task-selection skills are effective cognitive approaches to improve self-regulated learning. They observed that observing a human model engaging in self-assessment, task selection, or both could be effective for secondary education students' acquisition of the same and the acquisition, either through examples or through practice, would enhance the effectiveness of self-regulated learning.

Personality and motivation factors influence SRL

Concept of self-regulation is emerged from the research in personality psychology. Self-regulation affects all types goal directed behaviours of a person; when it is regarding learning behaviours it is called as self-regulated learning. There had been a number of researches analyzing the relationship between personality and self-regulated learning. The study conducted by Bidjerano and Dai (2007), regarding the relationship between the big-five model of personality and self-regulated learning strategies, reported that self-regulated learning strategies co-vary with personality dimensions. Use of time management, effort regulation and higher order cognitive skills shows high positive correlation to consciousness and intellect. Furthermore, self-efficacy for self-regulated learning is above and beyond previous academic achievement, gender, SES, intelligence, personality traits, and self-esteem in predicting academic achievement (Zuffiano et al, 2013).

Self-regulated learning is a motivation based learning theory; motivation is an essential component of self-regulated learning. Consequently many studies analyzed the function of different motivational factors in SRL. It is reported that need for achievement is a significant predictor of mastery-approach goals, and it is a significant predictor of metacognitive strategies. Also fear of failure is negatively associated to metacognitive self-regulation (Bartels & Magun-Jackson, 2009). Whereas metacognitive regulation strategies are found the strongest predictor of academic adjustment; self-regulated learning strategies, academic self-efficacy and test anxiety are also found as predictive of academic adjustment (Cazan, 2012). Another adverse factor, academic procrastination, is found to have negative correlation with intrinsic goal orientation, extrinsic goal orientation, metacognitive self-regulation, time/study environmental management and effort regulation (Motie, Heidari & Sadeghi, 2012). Self-efficacy for self-regulated learning is a stronger predictor of self-regulated learning than intelligence, personality traits, and self-esteem (Zuffiano et al., 2013). And accuracy in self-efficacy and self-evaluation correlated positively with performance (Ramdass & Zimmerman, 2008). But Lee, Lee and Bong (2014) observed that self-efficacy predicts self-regulation and achievement only when grade goals mediated the relationship, but individual interest functioned as direct predictor of self-regulation. Savoji, Niusha and Boreiri (2013) advocated that academic achievement can be predicted by dimensions of epistemological beliefs and motivational strategies and there is a positive relation between self-regulated learning strategies (cognitive, meta-cognitive) and academic achievement.

Disciplinary, Gender and individual differences in SRL

SRL is domain specific (Greene, Bolick, Jackson, Caprino, Oswald & McVea, 2015). There are variations in SRL across disciplines and gender, as the role of individual factors is vital in this approach. Among the diverse disciplines, minor mean differences is emerging in all the sub dimensions of SRL, students in different discipline differing in their use of self-regulatory strategies, though no clear regularity on any discipline's favour was perceived (Virtanen & Nevgi, 2010). Moreover female students are higher than male students in help-seeking strategies, utility value and on performance anxiety. Girls are showing significantly lower academic self-efficacy, interest and self-regulation in mathematics, than boys did (Lee, Lee & Bong, 2014). Low achieving students reported low level study strategies and low self-efficacy (DiFrancesca, Nietfeld & Cao, 2016). Students at high, average, and low grade point averages differed in overall use of SRL strategies (Nandagopal & Ericsson, 2012).

Groups based on intelligence and achievements do not differ significantly in SRL on short run but they differ significantly in SRL in long term (Sontag& Stoeger, 2016).

Interrelationship among self-regulated learning, self-efficacy and mathematics outcomes

SRL strategies are significantly correlating to secondary school student's performance of problem solving (Puteh & Ibrahim, 2010), fifth grade students' math competence (Friedrich, Jonkmann, Nagengast, Schmitz & Trautwein, 2013), female prospective teachers' academic achievement in mathematics; but it is not true for male prospective teachers (Acara & Aktamis, 2010).

Contextual differences in terms of gender and subject of study found to have effect on students' motivation and SRL; females possess less adaptive self-efficacy beliefs than males for learning mathematics (Wolters & Pintrich, 1998).They observed greater cognitive strategy use in social studies and English than mathematics. Effect of task value beliefs on performance outcomes is not significant as self-efficacy, and this is true for all contexts. But in the study conducted among seventh graders by Cleary and Chen (2009), girls reported more frequent use of self-regulation strategies than boys. They observed variations in students' motivation and use of self-regulation strategies across grade level; it diminishes towards higher grades.

Among the motivational beliefs in relation to SRL, self-efficacy, goal orientation, task value and epistemological beliefs were studied frequently. Many studies found that self-efficacy as a strong predictor of mathematics achievement (Wolters & Pintrich, 1998; Mousoulides & Philippou, 2005; Jaafar & Ayu, 2010), problem solving (Puteh & Ibrahim, 2010), and mathematics metacognition (Jaafar & Ayu, 2010), and found having significant correlation with self-regulated learning (Jain &Dowson, 2009; Usher, 2009; Puteh &Ibrahim, 2010). Cleary and Chen (2009) (among middle school students) and Mousoulides and Philippou (2005) (among pre-service teachers) observed task value as the primary motivational predictor of students' use of regulatory strategies during math learning where as Wolters and Pintrich(1998) observed that effect of task value beliefs on performance outcomes is not as significant as self-efficacy among seventh and eighth graders.

In an experiment among seventh graders, on instructional practice based on SRL, Pape, Bell and Yetkin (2003) observed that students are more able than previously to communicate mathematical understanding and justify their mathematical reasoning. It is also known that an integral part of developing students' SRL was to provide a context to support their growing awareness of themselves as agents in the learning process by supporting their strategic behaviours and to attribute outcomes to these behaviours.

It is possible to improve mathematical problem solving and self-regulation competencies of eighth grade students with higher learning competencies through short trainings (Perels, Gurtler & Schmitz, 2005). The same is proved in regular mathematics classroom (Perels, Dignath & Schmitz, 2009). Also, it is possible to support self-regulation competencies and mathematical achievement by self-regulation intervention within regular mathematics lessons of 6th-grade students (Perels, Dignath & Schmitz, 2009). SRL can be used for improving problem solving skills and pedagogical knowledge of prospective teachers (Bracha & Revach, 2009). Possibilities of self-regulated learning through the assistance of computers also were experimented. It is found that mathematics literacy can be improved through online metacognitive instruction (Kramarski & Mizrachi, 2006). Computer supported collaborative learning strategies also help to acquire self-regulated problem-solving skills in mathematics (Lazakidou & Retalis, 2010). Direct and indirect influences on SRL and its effects on mathematics outcomes revealed in research during 2000 to 2016 are portrayed in the Figure.1.

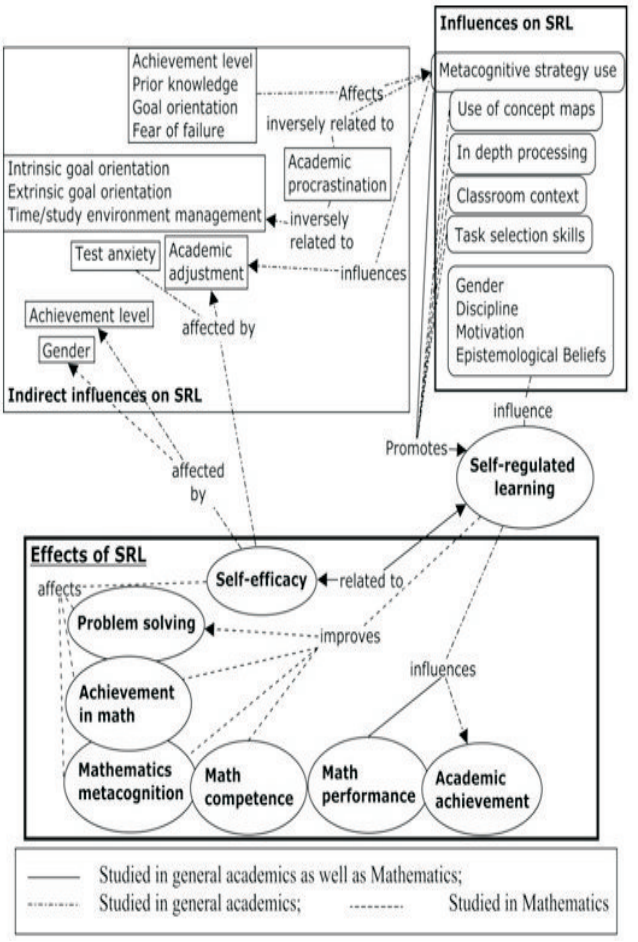

Figure 1. Direct and indirect influences on SRL and its effects on mathematics outcomes revealed in research during 2000 to 2016

VII. CONCLUSION

1. A host of cognitive and emotional factors within and outside the learner reciprocally impacts SRL in learners irrespective of level of education

The review demonstrated that self-regulated strategies, factors affecting self-regulatory behaviours and their relation to general academic outcomes are studied across all the three levels of education. There is moderate to strong effect of self-regulatory behaviours on academic outcomes including

academic adjustment, especially at secondary and tertiary levels, and teacher performance if used in teacher training. SRL strategies accounted for up to 51% of the variance in academic performance. Studies suggest that the strongest predictors tend to be the metacognitive regulation strategies. Studies evidence that in adult learners self-regulated learning strategies co-vary with personality dimensions. High Consciousness and Intellect are related to higher tendencies for the use of time management and effort regulation and higher order cognitive skills. High-interest students selected more main ideas and used more metacognitive strategies than low-interest students. Individuals profiled as predominantly rational engage in more self-reported metacognitive self-regulation than individuals profiled as predominantly empirical. Need for achievement was significantly related to metacognitive self-regulation, and mastery-approach goals partially mediated this relationship. Achievement goals, mathematics self-efficacy, and cognitive engagement have a mediating role between dimensions of epistemological beliefs and math achievement. Fear of failure was negatively associated with metacognitive self-regulation. Mastery-approach goals significantly predicted metacognitive strategies. Among high school students, academic procrastination was negatively correlated with metacognitive self-regulation, time/ study environmental management and effort regulation.

2. Self-efficacy and problem solving are studied closely in connection with SRL and found to enhance in-depth processing

Self-efficacy is one variable that is explored by many a studies in relation to SRL. Among middle schoolers, Self-efficacy and self-evaluation which are components of SRL correlated positively with math performance. Self-efficacy (SE) predicted self-regulation. Reciprocal relation between students' SE and SRL is fairly established. Other studies confirm unique contribution of SESRL on academic achievement above and beyond previous academic achievement, gender, SES, intelligence, personality traits, and self-esteem. Self-regulated learning enhances in-depth processing and thus performance on inferential questions and not for factual questions among middle school graders.

3. How gender, cultural context and discipline impacts SRL and consequent academic outcomes is not settled

Gender variation is evidenced in metacognitive strategies. Studies suggest that effect of gender on self-regulated learning is mediated by culture, discipline of study and age. In Asian cultures the females tend to manifest less regulatory behaviours especially in mathematics, though the same is not manifested in studies that used European and American samples. In a Korean study for example, Girls showed significantly lower academic self-efficacy, interest and self-regulation in mathematics. Females do not have adaptive self-efficacy beliefs as males for learning mathematics. However, other studies show that Female students scored moderately higher than male students on help-seeking strategies, utility value and on performance anxiety. Especially in maths, girls reported more frequent use of self-regulation strategies. Female high school students demonstrated positive relation between self-regulated learning strategies (cognitive, meta cognitive) and academic achievement. Among the diverse disciplines, minor mean differences emerged on all the sub dimensions of SRL though no clear regularity on any discipline's favour was perceived.

4. SRL can be enhanced even through short term regular classroom interventions

Practice would enhance the effectiveness of self-regulated learning. Self-regulated strategies can be enhanced through targeted interventions from kindergarten onwards; and it works even in teacher preparation. In Kindergarten, supporting classroom environments helps the learners to develop self-regulated learning. Among fifth and sixth graders- strategy training greatly enhanced students' self-regulatory judgments and thus performance. In this respect, context to support their growing awareness of themselves as agents in the learning process is identified as important. Among Secondary school students observing a human model engaging in self-assessment, task selection, or both could be effective for acquisition of self-assessment and task-selection skills.

5. Moderate to strong effects of self-regulation on mathematics related outcomes is evidenced

Review of studies on SRL in mathematics learning reveals that the most frequently used measure is Motivated Strategies for Learning Questionnaire. Studies evidenced that teachers are capable of differentiating between students' use of self-regulated learning. Self-efficacy is the variable studied in close relation to SRL in maths, followed by problem solving and achievement in nearly half the studies reported. Task value beliefs and anxiety are also studied. Especially in SRL in relation to mathematics, there is recent shift to experimental studies beyond the exploratory surveys. Also, in the case of maths outcomes in comparison to academic achievement in general, there are more studies among grade 6-8 students, with a lesser but significant number of studies at secondary and tertiary level. Studies that focused on grades below five are only one, with recent studies shifting into non-conventional samples as primary students and tertiary students. Self-efficacy and test anxiety varies according to gender and subject. There was greater cognitive strategy use in social studies and English than mathematics. Irrespective of level of education; Moderate to strong effects of self-regulation on mathematics related outcomes is evidenced. As with general learning, task interest was shown to be the primary motivational predictor of students' use of regulatory strategies during math learning. Likewise, self-regulation strategies are negatively related to mathematics anxiety.

6. Strategy training through methods including Computer-based instruction, semi-structured guidance, and face-to-face discussion enhances SRL in maths

Opportunities for self-regulated learning had a positive effect on students' cognitive activation and on students' emotional experience. Though it is difficult to train self-regulation compared to problem-solving competencies, it is possible to improve mathematical problem solving and self-regulation competence even through short training. Significant increase in metacognition and problem-solving of primary class students after Computer-based instructional method within an authentic context consisting of three main phases: observation, collaboration and semi-structured guidance are

observed. Among fifth and sixth graders strategy training greatly enhanced students' self-regulatory judgments and math performance. Thus in middle school level, it is possible to support self-regulation competencies and mathematical achievement by self-regulation intervention within regular mathematics lessons. Meta-cognitive guidance (online discussion without metacognitive guidance, face-to-face discussion) attained a higher level mathematical literacy. This is especially of significance as middle-school students exhibited a more maladaptive self-regulation and motivation profile than sixth graders, and achievement groups in seventh grade (high, moderate, low) were more clearly differentiated across both self-regulation and motivation than achievement groups in sixth grade. Also, by this level students perceive themselves as poorer self-regulators than younger students.

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