

**A Model of Cultivating Self-Regulated Learning and
Psychological Needs: Autonomy, Relatedness and
Competence
for Raising Mathematical Problem Solving Achievements**

**Inbal Koloshi-Minsker
School of Education**

Ph.D. Thesis

Submitted to the senate of Bar-Ilan University

Ramat-Gan, Israel

March 2017

Abstract

Solving math word problems is an essential component in elementary school mathematics curriculum (NCTM 2016; OECD-PISA, 2013). However, students tend to fail, not always due to lack of mathematical knowledge, but as a result of lack of self-regulated learning skills (Kramarski, Weisse, & Kololshi-Minsker, 2010).

The SRL (Self-Regulated Learning) is a multi-dimensional structure that emphasizes the active role of students in directing learning processes in components: cognition, metacognition, and motivation (Pintrich, 2000a,b,c; Zimmerman, 2000). While most SRL studies focused on the components of cognition and metacognition, few have studied the direct impact of the motivational component on mathematics achievement (Mevarech & Kramarski, 2014). Studies that investigated the impact of motivation, focused on motivation for learning with emphasis on skills and less on the emotional-psychological field of students, i.e. will.

The SDT (Self-Determination Theory) emphasizes the importance of nurturing the students' emotional-psychological field in their learning environment by cultivating the three basic psychological needs of the learner: Autonomy, Belonging, and Competence (Ryan & Deci, 2000a,b). A strong link was found between learners' competence in the emotional-psychological domain, and their learning capabilities and achievements (De Corte, Verschaffel, & Op' t Eynde, 2000; Hoffman, 2010; Pintrich & Schunk, 2011); this finding reinforces the importance of cultivating the metacognitive self-regulation by combining both theories, both from the aspect of skill and in relation to motivational-emotional factors that focus on the student himself – will (Zimmerman, 2008). However, these connections with their conclusions were conducted in separate studies on each theory and mostly conducted amongst higher age groups.

To date, a comprehensive study has not yet been conducted to examine the relationship between all the components of self-directed theories (SRL and SDT) in one study and one age group.

Therefore, the purpose of the first study is to deepen the understanding of the relationship between the components of the two self-regulation theories: SRL (Cognition, Metacognition and Motivation for learning), SDT (Autonomy, Belonging, and Competence) and between the achievement of solving mathematical problems in

mathematics by examining a theoretical model for understanding the direct and indirect relationships between the components among young students in primary school - an age group that was less studied in the studies that examined these theories.

Furthermore, in order to examine the effectiveness of the theoretic model, the purpose of the second study is to examine the effect of the three intervention programs based on an integration of the two self-regulation theories, and each one separately (SRL+SDT, SRL, SDT) on achievements in solving math word problems (routine problems and innovative problems, including: solving complex problems, producing routine problems – near transfer, and solving a challenging problem – remote transfer); the use of self-regulated skills in learning SRL, the sense of satisfaction of basic psychological needs SDT, and its components in mathematics lessons (general effect), and while solving math word problems (specific effect); as well as positive emotions in math lessons (general effect) among young students in primary school.

The intervention programs that were based on the self-regulation learning theory: SRL+SDT and SRL were based on theoretical and practical models of the SRL theory, by direct practice of self-questions (Anderson, 1993; Mevarech, & Kramarski, 1997, 2014; Nesher, 2002; Pintrich, 2000a,b,c; Polya, 2013; Schraw, 1998; Segal, 2002; The Ministry of Education, 2006; Zimmerman, 2000).

The intervention programs that followed the self-regulation theory (psychological needs): SRL+SDT and SDT, were based on theoretical and practical models of the SDT theory through direct practice in a "needs supporting dialogue" as well as nurturing positive emotions (Kaplan and Assor, 2004; Deci & Ryan, 2000).

The research questions are:

What is the intensity of the relationship between SRL (self-regulated learning), SDT (sense of satisfaction of the basic psychological needs in self-regulation) and achievements in math word problem-solving?

To what extent does each of the three intervention programs (SRL+SDT, SRL, SDT) effect on mathematic achievements, on self-regulated learning – SRL and on the sense of satisfaction of the basic psychological needs in self-regulation – SDT, in mathematics lessons (general effect), and while solving math word problems (specific effect)?

For the purpose of the first study, 737 students in first to sixth grade were exposed to both the SRL and SDT theories. The students were tested in achievement tests in solving math word problems, according to the mathematics curriculum (Ministry of Education, 2006) as well as self-report questionnaires to examine the use of SRL and SDT skills and while solving math word problems.

To examine the purpose of the second study, 383 students participated from state primary schools from third and fifth grades which were randomly sampled. The students were tested in achievement tests in solving math word problems, and completed a set of self-report questionnaires and measurement rules (filled-out in real time) to examine the use of SRL and SDT skills in mathematics lesson (the general effect of the intervention programs) and while solving math word problems (the specific effect of the intervention programs).

In response to the first research question, it was assumed that strong connections were found between the components of theories and the self-regulation theories' primary constructs, both SRL and SDT. Furthermore, a strong positive correlation was found between SRL and SDT, indicating a theoretical connection between these two constructs. In addition, SRL has directly and positively impacted the achievements in solving routine math word problems. According to the hypothesis, SDT's effect on achievements is mediated through SRL. When achievements in mathematics before intervention and students' grade level were statistically controlled – the effect of SDT was found to be negative, relatively low but significant. This negative finding may indicate a differentiated effect of SDT on students' achievements in the lower grade levels of primary schools, as compared to students in higher grade levels, while SRL is in the present study more influential in the achievement of solving the math word problems in higher grade levels. The distinct contribution of SRL and SDT to achievement contributes to literature that is controversial in its conclusions concerning the appropriate age for beginning to cultivate SRL-self-regulated learning among young students, based on both SRL and SDT theories (Mevarech & Kramarski, 2014; Veenman et al., 2006). On the other hand, this finding strengthens the need to begin at lower grade levels to cultivate self-regulation based on emotional-motivational aspects (i.e., fulfillment of students' feelings of autonomy, belonging, and competence) and based on them – to continue teaching SRL skills (cognition, metacognition, and learning motivation).

In response to the second research question, it was found that the effect of the intervention programs of the study (SRL+SDT, SRL, SDT) on students' achievements in solving math word problems was consistent with the theoretical model. Students that have been exposed to the integrated intervention program SRL+SDT achieved the higher achievements, both in solving routine problems and innovative ones, some of which required performing the transfer (near and far).

On the basis of the data it can be concluded that students actually applied all their learning skills: cognitive, metacognitive and learning motivation SRL as well as their emotional abilities SDT (will) while solving the math word problems. Additional support to the theoretic model lies in the fact that students belonging to the SRL intervention group only, achieved higher achievements than those of the students belonging to the SDT intervention group only.

The self-report questionnaires and measurement rules (in real time) revealed that the extent of use of SRL skills of students in the integrated SRL+SDT and SRL-only intervention groups was similar, both in math lessons (general effect of the program) and while solving math word problems (specific effect). However, students belonging to the SDT-only intervention group reported the strongest feeling of satisfaction of their basic psychological needs, especially the autonomy element both in math lessons (general effect of the program) and while solving math word problems (specific effect). These findings have an important impact on the optimal planning of learning environments that support autonomy (Kaplan & Assor, 2012; Katz & Assor, 2002).

In summary, the main conclusion of the present study reinforces the need to nurture the components of the two self-regulation theories of SRL and SDT among primary school students, both to raise their achievements in solving math word problems (routine and innovative) and to implement the acquired self-regulation skills (specific effect) to new assignments and unfamiliar situations (general effect). This means that the role of the educational system is to build learning environments that nurture students' self-regulated learning skills (SRL), and that allow fulfillment of the emotional-psychological need (SDT), thereby increasing their learning achievements and training them to cope with diverse challenges in their lives (Efklides, 2011).

According to this educational concept, the present research has contributions in three fields:

The theoretical contribution of the study is to establish the links between the theories of self-regulation SRL and SDT and their components, among them and their achievements in solving math word problems among primary school students (as opposed to other studies that focused on a single age or higher age group).

The methodological contribution of the study lies in the new evaluation tools that were built, processed and validated: Achievement tests (solving math word problems); self-report questionnaires to examine the overall effect of the intervention programs in math lessons and the specific effect while solving math word problems, as well as measurement rules (SRL, SDT) to examine judgment and evaluation skills when solving math word problems in real time. These research tools may provide a starting point for the construction of the intervention programs.

The practical contribution is the integrated intervention program SRL+SDT to improve achievements in solving math word problems by fostering self-regulated learning skills (SRL) and fulfilling students' basic psychological needs (SDT). The intervention program may help to raise achievements in additional knowledge domains and among other populations of students.

In summary, suggestions for further future research are proposed.