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The Effect of Problem-Based Learning on Self-Regulated Learning: A Review of Literature

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Abstract

The purpose of this paper is threefold. Firstly, self-regulated learning is described from the social cognitive perspective and why self-regulated learning should be targeted in schools is discussed. Secondly, problem-based learning is proposed to facilitate self-regulated learning. Literature on the effects of problem-based learning on students' self-regulated learning in K-12 science classes is reviewed. An empirical base for how particular aspects of problem-based learning can improve students' self-regulated learning is provided. Finally, based on the reviewed literature, limitations in the specified research area are addressed and some recommendations for further research are offered.

Key words: *problem-based learning, science education, self-regulated learning.*

Introduction

Self-regulation is defined as "self-generated thoughts, feelings, and actions that are planned and cyclically adapted to the attainment of personal goals" (Zimmerman, 2005, p. 14). Self-regulation is a self-directive process. In each learning task, self-regulated learners selectively use specific processes: they set specific goals, adopt strategies to achieve their goals, monitor their performance, restructure environment so that it is suitable for the goals, manage time well, self-evaluate their methods, make cause-effect relationships, and adjust future methods (Zimmerman, 2002).

Social cognitive perspective views self-regulation as interaction of personal, behavioural, and environmental processes (Bandura, 1986 as cited in Zimmerman, 2005). Zimmerman (2002, 2005) explained self-regulation as a cyclic process. Accordingly, *three phases of self-regulation* are forethought, performance or volitional control, and self-reflection phases, which refer to the processes and beliefs *before* learning efforts, *during* implementation of the behaviour, and *after* learning efforts, respectively.

The forethought phase involves task analysis and self-motivation beliefs. Task analysis refers to students' setting goals and making strategic plans (Zimmerman, 2005). Research indicated that effective goal setting enhances self-efficacy and self-regulation. Properties of the goal: specificity (i.e., goals that incorporate specific performance standards rather than general goals like doing one's best), proximity (i.e., short-term goals rather than distant, long-term goals), and difficulty (i.e., goals of moderate difficulty) are critical in enhancing self-regulation (Schunk, 2001). Moreover, a self-regulated learner is able to adjust goals and select appropriate strategies to adopt the altering conditions in intrapersonal, interpersonal, and contextual factors (Zimmerman, 2005). Motivating oneself is crucial at this point because, besides knowing regulatory skills in detail, self-regulated learner needs self-motivation to implement that knowledge. Self-motivation beliefs involve self-efficacy beliefs, outcome expectations, task value beliefs (i.e., intrinsic value, attainment value, and utility value) and goal orientation (Zimmerman, 2002; 2005). Self-efficacy is individuals' judgment of their ability to succeed in given tasks (Schunk, 1991). Research indicated that students' self-efficacy beliefs are related to their achievement and their level of self-regulation (Schunk, 1991; Zimmerman & Martinez-Pons, 1988, 1990). Intrinsic motivation refers to "motivation to get engaged in an activity for its own sake" (Pintrinch & Schunk, 2002, p. 245). The intrinsically motivated individuals work on the task because the task is enjoyable for them (Zimmerman, 2002; 2005). Task value includes four components: attainment value, intrinsic interest or intrinsic value, utility value, and cost belief. Attainment value is related to the importance of the task for the individual while intrinsic interest is related to the enjoyment due to the engagement in the task. The usefulness of the task for the individual's prospective plans is addressed in utility value whereas the individual's perception of the negative costs associated with the task is referred as cost belief. These four components function together and constitute the value individual attaches to the task (Wigfield & Eccles, 1992, as cited in Pintrich & Schunk, 2002). Research indicated that task value is positively related to achievement (e.g., Yumusak, Sungur, & Cakiroglu, 2007). Another component of the motivation beliefs is goal orientation. Goal orientation refers to students' reasons or purposes for engaging in achievement behaviour (Ames, 1992; Dweck, 1986; Nicholls, 1984). The two main goal orientations are mastery and performance goal orientations (Ames, 1992). Students who pursue mastery goals value learning itself and are concerned with improving their competence. Believing that hard work will bring them success, they are more likely to persevere with learning activities (Ames, 1992; Meece, Blumenfeld, & Hoyle, 1988). However, students who adopt performance goals consider learning as a way of demonstrating ability to others (Ames, 1992; Ames & Archer, 1988; Meece, Blumenfeld, & Hoyle, 1988). Research findings generally revealed that students who are mastery goal oriented demonstrate more adaptive patterns of behaviour such as higher levels of cognitive engagement, academic efficacy, self-regulated learning, and lower levels of disruptive behaviour

(Anderman & Maehr, 1994; Elliot & Harackiewicz, 1996; Kaplan, Gheen, & Midgley, 2002; Maehr & Midgley, 1991; Middleton & Midgley, 1997).

The performance phase of self-regulation is composed of self-control and self-observation. In self-control, learner uses strategies selected during the forethought phase. Self-control encompasses processes of self-instruction (i.e., one is describing how to carry out a task as one is performing the task), imagery (i.e., constructing mental pictures), attention focusing (i.e., improvement of one's concentration), and task strategies (i.e., one is dealing with the necessary parts of the task). Self-observation - the other component of performance phase - involves self-recording and self-experimentation. Timely self-feedback serves for taking corrective actions. On the other hand, inaccurate self-observations such as individuals' misperceiving or distorting their actions do not contribute to corrective actions. When individuals get diagnostic information in their actions, they can systematically change aspects of their functioning and engage in personal experimentation (Zimmerman, 2005).

The third phase - *self-reflection* - involves self-judgment and self-reaction. Self-judgment is related to one's self-evaluating of performance and making causal attributions. Individuals compare the information they get from self-observation against some criteria which might be mastery, previous performance, normative, or collaborative. Individuals' self-evaluations are connected to causal attributions about the results of their activities, such as attributing poor performance to insufficient effort or low ability. For instance, attributing a failure to the use of specific strategy leads individual to adopt one's strategy. Since strategies can be corrected, this attribution serves to sustain motivation and protect against negative reactions. Self-reaction involves self-satisfaction and adaptive inferences. Self-satisfaction is important because individuals follow the actions which produce satisfaction. Adaptive inferences are related to individuals' interpretations about how they will take steps to regulate following actions and adaptive inferences lead individuals to potentially better forms of self-regulation, such as adjusting their strategies (Zimmerman, 2005). On the other hand, defensive inferences, referred to as self-handicapping strategies, undermine successful adaptation. Covington (1992) described self-handicapping as "the creation of some impediment to one's performance – either imagined or real – so that the individual has a ready excuse for potential failure" (p. 85). Self-handicapping strategies can be procrastination (postponing a task by providing some irrational reasons), setting unattainable goals, and rejecting the task by lowering the importance of the task. Although a temporary relief is provided, it is likely that self-handicapping strategies undermine students' performance (Covington, 1992). Research indicated that self-handicapping is related to low achievement, increased withdrawal, and poor study habits (Midgley & Urdan, 1995; Urdan & Midgley, 2001). Individuals' self-reflections about the events influence following forethought phase, thus forming a cyclic process (Zimmerman, 2005).

Why Self-Regulated Learning Should Be Targeted in Schools?

The international monitoring studies of TIMSS (Third International Mathematics and Science Study) and PISA (Program for International Student Assessment) demonstrated that students' science achievement is far below the expected levels. Moreover, research indicated that students' motivation in science decreases with age (Guvercin, 2008; Pell & Jarvis, 2001; Senler & Sungur, 2009). Borkowski and Thorpe (1994) asserted that self-regulatory deficiencies can be the reason for underachievement because underachievers are less accurate in assessing their abilities, set lower academic goals, concentrate more on the negative aspects of their activities and are more self-critical, have lower self-efficacy about their performance, and do not persist on learning activities unlike achievers. In contrast, self-regulated learners effectively set goals for themselves, select and use strategies to attain their goals, and monitor results of their actions. They are self-efficacious, committed to attain necessary knowledge and skills, and more likely to seek social assistance when needed (Risemberg & Zimmerman, 1992; Zimmerman & Martinez-Pons, 1988). High achievers use SRL strategies more effectively than low achievers (Risemberg & Zimmerman, 1992; Zimmerman & Martinez-Pons, 1990).

Due to powerful features of self-regulated learner, SRL receives attention of educational psychologists and policy makers (Boekaerts, 1999). Wolters (2003) characterizes self-regulated learners as "... autonomous, reflective, and efficient learners who have the cognitive and metacognitive abilities as well as the motivation beliefs and attitudes needed to understand, monitor, and direct their own learning" (p. 189). In order to regulate their learning, self-regulated learners use a variety of cognitive strategies (rehearsal, elaboration, organization), metacognitive strategies (planning, monitoring, regulation), and resource management strategies (Pintrich, 1999). They have knowledge of skill, behavioural skill, and self-motivation as well as skills to implement that knowledge effectively. Being aware of their strengths and weaknesses, self-regulated learners selectively use strategies in order to attain personally set goals. They monitor their behaviours and make self-reflection. If they are progressing towards their goals, this enhances their self-satisfaction and motivation (Zimmerman, 2002), but if they are not progressing, they may need to change their strategies (Horner & Shwery, 2002). In fact, good self-regulated learners *actively* manage their cognitions, affects, and behaviours so that they are moving towards their goals (Schunk & Zimmerman, 2008; Wolters, 2003). This active engagement in their own learning process makes self-regulated learning a critical factor (Patrick & Middleton, 2002). By enhancing their skills, self-regulated learners can adapt to requirements of the dynamic context effectively (Zimmerman & Schunk, 2001). They develop knowledge, skills, and attitudes that can be transferred from one learning context to another in school and beyond (Boekaerts, 1999). Thereby, self-regulated learning has been considered to foster individuals' lifelong learning (Schraw, Crippen, & Hartley, 2006; Zimmerman, 2002).

Although one of the main goals of education system should be developing students' self-regulatory skills (Boekaerts, 1997; Puustinen & Pulkkinen, 2001; Schraw, Crippen, & Hartley, 2006), few teachers support students' self-regulation in their classes (Randi & Corno, 2005; Zimmerman, 2002). Teachers rarely encourage students to set goals, give them opportunities to choose academic tasks, or promote students to self-evaluate their work (Zimmerman, 2002). Therefore, there is a need for identifying instructional approaches which promote students' self-regulation: self-regulation is more likely to be developed when students' autonomy is supported, the task is motivating, and the connection between effort and success is highlighted in the learning environment (Paris & Paris, 2001; Sungur & Gungoren, 2009). The traditional approaches which expect students to passively receive knowledge and skills transmitted by the teacher (Boekaerts, 1997) do not meet the needs of rapidly changing knowledge base, theory, and practice. In contrast, the contemporary approaches put students in a place that requires learners to construct their own knowledge (Savery, 2006). Problem-based learning (PBL), one of the contemporary approaches to learning with its theoretical roots in constructivism, has potential to improve students' self-regulation. PBL places responsibility on students for their own learning by giving them control over what to study and how to study (Paris & Paris, 2001). The paper continues with description of PBL instruction and explains how PBL can promote students' self-regulation. Next, research investigating effects of PBL in K-12 science is reviewed. The overarching purpose of the present study is to provide empirical evidence from the literature for the effectiveness of PBL on the development of student's self-regulation.

Problem-Based Learning

PBL was initially developed for medical school students in the late 1960s and, due to its advantages, has been applied in high, middle, and elementary schools (Evenson & Hmelo, 2000). Savery (2006) defined PBL as "an instructional learner-centred approach that empowers learners to conduct research, integrate theory and practice, and apply knowledge and skills to develop a viable solution to a defined problem" (p. 12). PBL is a student-centred approach; students are introduced a problem which they inquire. The problems, often interdisciplinary, are ill-structured (i.e., complex, without easy answers), fascinating, and authentic (Barell, 2007). The problem to be solved generally connects to real-world problem (Kain, 2003). At the outset, students do not have the information to solve the problem, but as they deal with the problem, they start to understand the problem; define what they have already known and what they need to know to get a solution (Stepien & Gallagher, 1993). The role of teacher is facilitating students' learning by coaching on how to address questions and where to look for information. At the end, students propose a solution for the problem. PBL provides students with opportunities for the development of various skills; students collaborate with each other to solve the problem, develop critical thinking skills, learn to apply the knowledge, and relate it with daily life experience. Students are expected

to apply the knowledge and demonstrate metacognitive skills such as monitoring their own understanding. They become responsible for their own learning and turn into self-directed learners (Kain, 2003; Savery & Duffy, 1995).

Specific features of PBL are believed to facilitate particular aspects of self-regulated learning. At the very beginning of the PBL, students are presented a real-problem which has personal relevance to them. Students tend to engage more with a real problem that is familiar to them (Savery & Duffy, 1995) because real-world problems *motivate* students to work on the concepts and principles they need to know to solve the problem (Duch, Groh, & Allen, 2001). Thus, working on real problems is believed to be engaging and interesting for students and to foster students' *intrinsic value* to learn (Loyens, Magda, & Rikers, 2008). The teacher with a role of facilitator avoids giving information, but asks questions to probe students' knowledge (Savery & Duffy, 1995). By asking what they know about the problem scenario, the teacher aims to familiarize students with *metacognitive questions* (Stepien & Gallagher, 1993). As students analyze the problem, they identify relevant facts from the scenario and generate hypotheses about possible solutions. Students also identify knowledge deficiencies relative to the problem and then search on these deficiencies (Hmelo-Siver, 2004). While analyzing the complex problems and inquiring for the solution, they are involved in *critical thinking* (Duch, Groh, & Allen, 2001). As time passes, students get experienced in *assessing* what they know, identify what they need to know, and use appropriate resources (Duch, Groh, & Allen, 2001; Stepien & Gallagher, 1993). They gather information, and collaborate on the evaluation of hypotheses according to the data they collected (Stepien & Gallagher, 1993). Assessment is an important issue because it promotes *planning* and *regulation* of future efforts (Zimmerman, 2005). After the evaluation of new knowledge, if students decide that it is insufficient for the solution of the problem, they formulate additional learning issues to search on. Meanwhile, students *make reflection* on the activities they have performed (Hmelo & Lin, 2000). Reflection and evaluation of their work promote feelings of ownership and responsibility for learning (Paris & Paris, 2001). By directing their own learning, such as deciding on what information they need, students have the major responsibility for learning (Savoie & Hughes, 1994). By placing responsibility on the students, PBL both demands and supports SRL (Paris & Paris, 2001). Group work gives students opportunity to develop *interpersonal* and *communication skills,* and students become good collaborators (Duch, Groh, & Allen, 2001; Hmelo-Silver, 2004). PBL also requires students to demonstrate what they have learned through a product or performance (Savoie & Hughes, 1994). Thus, at the completion of each problem, students *reflect* on the knowledge they have gained. In summary, PBL stimulates students' motivation by providing students with authentic problem-scenarios which are connected to their lives, and by giving greater ownership of their learning, such as deciding on what information they need or which resources to search on (Savoie & Hughes, 1994; Paris & Paris, 2001). PBL promotes students' active engagement in the learning process by using cognitive and metacognitive learning strategies, such as

monitoring their own understanding, and PBL supports students' collaboration through group work (Savery & Duffy, 1995). In fact, throughout the PBL processes, students develop skills which are essential to become continual learners (Duch, Groh, & Allen, 2001). However, there is limited research evidence supporting the effectiveness of PBL on students' SRL. The main purpose of the present study is to review empirical research investigating the effects of PBL on different aspects of SRL in K-12 science and provide evidences for its effectiveness on the development of SRL. Limitations in the specified research area will be addressed and suggestions for further research will be offered.

Methods

For the purpose of the present study, past research which implemented PBL in K-12 science classes and investigated its effects on students' self-regulation were reviewed. The literature was searched through Eric and Academic Search Complete databases with different combinations of key words of "problem-based learning", "self-regulation", "motivation", "learning strategy", and "metacognition" and the search was restricted to presence of the keywords in abstracts. Four studies met the inclusion criteria. References of these studies were further examined and an expert in the PBL and SRL field was consulted for any other relevant study, which yielded one more study.

Results

The literature search described above located five studies that investigated effectiveness of PBL on SRL in K-12 science classes. While two of these studies were qualitative, three of them followed quantitative approach. Main characteristics and findings of these studies are summarized in Table 1 which will be further discussed throughout the paper.

Sage's (1996) study examined the effect of PBL in a case study. Three classes (one combined first and second grade, one combined third and fourth grade, and one eighth grade) from two schools participated in the study. Students were introduced with ill-structured problems on which they inquired. Teachers, who were experienced with PBL instruction, used KWL strategy (What do you think you know? What do you want to know? What have you learned?), and provided some materials for students to search. Students conducted many experiments and recorded findings. They also had opportunity to ask questions to an expert who visited the class. At the end students presented their solutions to the class. Data were collected through classroom observations, semi-structured interviews, student work during PBL experience, and teacher reflections. Students generally stated that they liked problems. In addition, teachers held positive thoughts about the PBL instruction. They mentioned improvement in their students' higher order thinking skills and problem solving skills, and students' learning not only the core concepts but also the related concepts. The author suggested that investigations about the implementation of PBL instruction in elementary and middle school settings should be continued.

More recently, another case study was conducted by Chin and Chia (2006). They investigated how a class of grade 9 students (*N*= 39) deal with ill-structured problems related to food and nutrition topic in biology. Students formed heterogeneous groups in terms of ability and race. Groups decided on what to study from the given topic. After making some readings and discussions, they identified the problem themselves. Then, they inquired for the solution, and lastly presented results. Project files, reflection logs, observations, audiotape and videotape recordings of class discussions, and students interviews were used as data sources. It was found that many students had difficulty in identifying the problem by themselves, but they were able to formulate problems after discussing with friends and family members. Researchers suggested that students can be given opportunity to negotiate with others outside the class in the problem identification stage. Although facing difficulties, most of the students liked to investigate the topics they generated in line with their personal interest. Another finding of the study was that ill-structured problem encouraged students to ask questions and these questions were very important since they determined what students learnt and how they learnt. Thus, students engaged in a self-directed inquiry. Authors suggested that, in order to help students generate useful questions, teachers can use graphic organizers and different sheets like need-to-know and mind map. Students analyzed the problem, decided on what they want to know, investigated multiple data sources like books, internet, surveys and interviews, reflected on their findings, and critically evaluated results. Moreover, students had opportunity to study multidisciplinary because of the ill-structured nature of the problem. Therefore, the study supported the use of ill-structured problems in PBL.

Table 1. *Studies that investigated effect of PBL on SRL in K-12 science*

Author and year	Research design	Number of classes and students	Grade level	Content domain	Results
Sage, 1996	Case study	3 classes	Combined 1st - 2nd grade, Combined 3rd - 4th grade, 8th grade	Plant Ecosystem	Improvement in students' higher order thinking skills, problem solving skills. Learning not only the core concepts but also the related concepts.
Chin & Chia, 2005	Case study	1 class, 39 students	9th grade	Food and nutrition	Difficulty in identifying the problem by themselves, but formulating problems after discussing with others. Increase in motivation due to studying topics of personal interest. Engagement in a self-directed inquiry. Investigating multiple data sources. Studying multidisciplinary.
Sungur & Tekkaya, 2006	Static-group pretest-posttest design	2 classes, 61 students	10th grade	Excretory system	Experimental group students scored higher than control group students on intrinsic goal orientation, task value, elaboration, critical thinking, metacognitive self-regulation, effort regulation, and peer learning.

Table 1. continued

Author and year	Research design	Number of classes and students	Grade level	Content domain	Results
Araz & Sungur, 2007	One-group pretest-posttest design	4 classes, 126 students	8th grade	Genetics	Reasoning ability, meaningful learning, and prior knowledge had positive direct effects on students' achievement while task value beliefs had negative direct effects. Learning approach mediated the relationship between reasoning ability and achievement, and also the relationship between task value and achievement.
Demirel & Arslan Turan, 2010	Static-group pretest-posttest design	2 classes, 42 students	6th grade	Body systems	Students in the experimental group reported statistically significantly higher level of attitude toward science, and higher levels of metacognitive awareness and motivation in science than students in the control group.

Among the quantitative studies, in a static group comparison research design, Sungur and Tekkaya (2006) investigated the effect of PBL on 10th grade students' self-reported motivation and learning strategy use in the unit of excretory system. Two intact classes were used in the study; one class (N= 30, $Mage$= 16.0 years) was assigned to experimental group and the other class (N= 31, $Mage$= 16.6 years) to control group, randomly. The number of students who participated in the study was 33 male and 22 female students. The control group received traditional instruction while the experimental group was taught with PBL over a six week period. Students in the experimental group worked in small heterogeneous groups in terms of learning style, academic performance, and gender. They were given ill-structured problems about a patient's case. Students discussed on the problem, identified the facts, made predictions, and decided on what information they needed. Then students decided on which resources to use in order to get information such as books, internet, and experts. After getting information, students shared what they had acquired with group members. Students revised their former ideas according to the new information and generated new learning issues. The process continued until they believed that they had sufficient information. Although there was no difference between the experimental and control groups on pretest results, MANOVA analysis conducted on posttest data revealed that there were statistically significant differences between the groups in terms of some of the motivation and use of learning strategy variables. Specifically, it was found that experimental group students scored higher than their control group peers on intrinsic goal orientation, task value, elaboration, critical thinking, metacognitive self-regulation, effort regulation, and peer learning. The researchers concluded that the PBL instruction supported students' self-regulatory skills and suggested to integrate it in science curriculum.

Relationships among some cognitive and motivation variables in a PBL environment were investigated by Araz and Sungur (2007). Four 8th grade intact classes (*N*= 126) of an urban middle school participated in the study while no control group was included. 60 male and 66 female students, ranging in age from 13 to 15, were participants of the study. The authors examined the relationships among reasoning ability, learning approach (deep-meaningful learning and surface-rote learning), prior knowledge, motivation variables, and achievement in genetics by developing and testing a conceptual path model. The analysis revealed that reasoning ability, meaningful learning, and prior knowledge had positive direct effect on students' achievement in genetics while task value beliefs had negative direct effect. The researchers asserted the need to measure task value as three separate components of importance value, utility value, and intrinsic interest rather than as a composite variable of overall task value. Analysis also revealed that learning approach mediated the relationship between reasoning ability and achievement, and also the relationship between task value and achievement. It was found that cognitive variables were better predictors of achievement scores than motivation variables since they explained greater proportion of variance in the achievement. Totally, 23% of the variance in the achievement scores was accounted for by its relationship with learning approach, prior knowledge, task value beliefs, and reasoning ability.

In another research from Turkey, Demirel and Arslan Turan (2010) investigated effectiveness of PBL on 6th grade students' attitude toward science, metacognitive awareness, and motivation in the unit of our body systems. Two intact classes from a private school were randomly assigned to experimental group (*N*= 23) and control group (*N*= 19). 23 male and 19 female students participated in the study. Pretest comparisons revealed that the groups were similar to each other in terms of achievement, attitude, metacognitive awareness, and motivation level. The control group was taught in line with the principles indicated by the Ministry of National Education while the experimental group received the PBL instruction. The study lasted 8 weeks. Three problem scenarios were given to experimental group students. Science and Technology teacher guided students for inquiry. Students discussed on the problem and generated hypotheses. The teacher asked students which information they needed in order to solve the problem and they listed issues they needed to learn. Students used library and computer laboratory for their research and shared findings with group members. On the basis of their research and discussions, they formulated solutions. At the end of the intervention, posttests were given. Independent samples t-tests revealed that students who received the PBL instruction reported statistically significantly higher level of attitude toward science, and higher levels of metacognitive awareness and motivation in science. The researchers asserted that PBL provides students with a positive environment to collaborate and gives them opportunity to study topics in which they have interest. However, due to the small sample size, generalizability of the study was low and researchers pointed out the need for investigating the effectiveness of PBL with larger samples.

Conclusions

The aforementioned studies provide empirical evidence that PBL has potential to support different aspects of students' self-regulation in science. More specifically, they reveal that the PBL environment provides students with opportunity to study topics they have interest in, which motivates them; students work in groups and interact with their friends; search multiple sources of information; and learn more than core concepts due to the ill-structure of the problem (Sage, 1996; Chin & Chia, 2006). Furthermore, students' use of cognitive strategies, motivation, metacognitive awareness, and attitude toward science improve in the PBL environment (Sungur & Tekkaya, 2006; Demirel & Arslan Turan, 2010). These findings support PBL's effectiveness in developing students' SRL. Indeed, in their study, Cakir and Tekkaya (1999) suggested the implementation of PBL in science classes. They asserted that PBL provides challenges for students to learn while dealing with real problems, which enhances their interest in science, helps them improve their problem-solving skills, learn multidisciplinary approach to study science, and cooperate with each other. The researchers obviously pointed out the need for adopting science curricula and instruction according to the premises of PBL. We also believe that PBL environment can contribute to students' construction of their own knowledge and give students opportunity to learn how to deal with the problems such as those they will encounter in real life. Individuals need to be good at regulating their cognition, motivation, and behaviour so that they can effectively manage challenges in their lives and, based on the reviewed literature, it can be asserted that PBL environment is suitable for students to develop their self-regulatory skills.

Recommendations for Future Research to Examine Effectiveness of PBL on SRL

Based on the literature review, there seems to be some limitations in the research area examining the effect of PBL on students' SRL. In order to improve research in the area, some recommendations are offered:

1. Experimental studies generally did not use random assignment of subjects to groups. Those studies included intact classes but, while doing so, some of them examined if there were any pre-existing differences between groups. If randomization is not possible, providing evidence for the equality of control and experimental groups, or otherwise procedures employed to equate groups at the beginning of the study is advocated.
2. Researchers tended to report merely statistical significance of their test results; however, practical significance is also important in order to make meaningful interpretations of the magnitude of differences in quantitative studies. Therefore, we encourage researchers to report effect size values and compare them with previous research findings.

3. Majority of the research used biology topics, but physics and chemistry topics also warrant investigation so that the effectiveness of PBL can be discussed on more extensive science topics. SRL strategies employed by the individuals are connected to the domain they are used in because the domain, to some extent, designates the more functional strategies. It is needed to investigate whether SRL strategies can be transferred and/or whether some modifications are needed so that they can be used as effectively in different domains (Zeidner, Boekaerts, & Pintrich, 2005).
4. Researchers mainly focused on the forethought phase of the self-regulation cycle such as goal setting and intrinsic interest or value. However, researchers can also investigate the aspects of performance and self-reflection phases. Recently developed online event measures of trace logs, think-aloud protocols, structured diaries, observations, and microanalytic measures may allow researchers to study self-regulation in real time and may provide information about the changes and trends in students' self-regulation (for an extensive overview see Zimmerman, 2008).
5. We wonder if any aptitude-treatment interaction can exist regarding the effect of PBL on SRL, that is, students with different characteristics may be affected differently by PBL. Koran and Koran (1984) pointed out prior learning experience, general ability, anxiety, and achievement motivation as potential aptitudes to be considered in science education research. Whether PBL is equally effective on students with different characteristics or whether, depending on certain characteristics, some modifications in the PBL instruction, such as variations in the amount of scaffolding provided are needed, deserves investigation.

Limitations of the current study

The current study reviewed empirical research on the effectiveness of PBL on SRL in K-12 level. The findings may not be applicable for other grade levels. In addition, the findings may show variations depending on some student characteristics, such as personality and ability. Since there was a limited available literature, it was not possible to examine such possible differences in the current study. Moreover, the present study could not shed light onto whether the effectiveness of PBL on SRL differs depending on domains (i.e. physical sciences, life sciences, social sciences, or language) due to the limited number of research.

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Učinak učenja rješenjem problema na samoregulirano učenje: pregled literature

Sažetak

Cilj ovog rada je trostruk. Prvo, samoregulirano učenje se opisuje iz društveno-kognitivne perspektive i raspravlja se o tome zašto treba težiti samoreguliranom učenju u školama. Drugo, pretpostavlja se da učenje rješenjem problema olakšava samoregulirano učenje. Navodi se pregled literature o učincima učenja rješenjem problema na samoregulirano učenje u nastavi K-12 znanstvenih sadržaja. Pružena je empirijska osnova za istraživanje razine do koje određeni aspekti učenja rješenjem problema unaprjeđuju samoregulirano učenje. Konačno, na temelju pregledane literature, navedena su ograničenja u tom specifičnom istraživačkom području te ponuđene neke preporuke za daljnja istraživanja.

Ključne riječi: *učenje rješenjem problema, obrazovanje u području znanosti, samoregulirano učenje.*

Uvod

Samoregulacija se definira kao ,,samopoticane misli, osjećaji i aktivnosti koje su planirane i ciklično se prilagođavaju postizanju osobnih ciljeva" (Zimmerman, 2005, str. 14). Samoregulacija je proces usmjeren k samom pojedincu. Kod svakoga zadatka učenja, samoregulirani učenici selektivno se koriste specifičnim procesima: postavljaju specifične ciljeve, prilagođavaju strategije postizanju ciljeva, nadgledaju rezultat, restrukturiraju okolinu u skladu sa ciljevima, dobro organiziraju vrijeme, sami vrednuju svoje metode, uspostavljaju uzročno-posljedične odnose i određuju buduće metode (Zimmerman, 2002).

Promatrano iz društveno-kognitivne perspektive, samoregulacija je interakcija osobnih i procesa ponašanja te procesa u okolini (Bandura, 1986, citirano u Zimmerman, 2005). Zimmerman (2002, 2005) objašnjava samoregulaciju kao ciklični proces u *tri faze*, a to su promišljanje, izvedba ili voljni nadzor te samorefleksija, koje se odnose na procese i uvjerenja što prethode naporima uloženim u učenje, prate primjenu ponašanja i slijede poslije uloženih napora.

Faza promišljanja obuhvaća analizu zadatka i samomotivacijska uvjerenja. Analiza zadatka odnosi se na učenikovo postavljanje ciljeva i pripremu strategijskoga plana (Zimmerman, 2005). Istraživanja pokazuju da djelotvorno postavljanje cilja unapređuje samoučinkovitost i samoregulaciju; specifičnost (ciljevi koji sadrže specifične standarde izvedbe umjesto općih ciljeva kao što je učiniti nešto na najbolji mogući način), blizina (kratkoročni ciljevi umjesto dalekih, dugoročnih ciljeva) i težina (umjereno teški ciljevi) su kritični za bolju samoregulaciju (Schunk, 2001). Štoviše, samoregulirani učenik može prilagoditi ciljeve i odabrati odgovarajuće strategije da bi prihvatio promjenljive uvjete intrapersonalnih, interpersonalnih i kontekstualnih čimbenika (Zimmerman, 2005). U toj točki ključno je motivirati samoga sebe jer, osim detaljnoga znanja o vještinama regulacije, samoreguliranom učeniku potrebna je samomotivacija da bi to znanje primijenio. Samomotivirajuća uvjerenja obuhvaćaju uvjerenja o vlastitoj učinkovitosti, krajnja očekivanja, uvjerenja o vrijednosti zadatka (intrinzična vrijednost, vrijednost postignuća i korisna vrijednost) te usmjerenost ka cilju (Zimmerman, 2002; 2005). Samoučinkovitost se odnosi na prosudbu pojedinca o svojoj sposobnosti da bude uspješan u postavljenim zadacima (Schunk, 1991). Istraživanja pokazuju da su uvjerenja učenika o njihovoj vlastitoj učinkovitosti povezana s njihovim postignućima i razinom samoregulacije (Schunk, 1991; Zimmerman i Martinez-Pons, 1988, 1990). Intrinzična se motivacija odnosi na „motivaciju za sudjelovanjem u nekoj aktivnosti radi sebe samoga"(Pintrinch i Schunk, 2002, str. 245). Intrinzično motivirani pojedinci rade na zadatku jer im pruža zadovoljstvo (Zimmerman, 2002; 2005). Vrijednost zadatka sadrži četiri elementa, a to su: vrijednost postignuća, intrinzično zanimanje ili intrinzična vrijednost, korisna vrijednost i uvjerenje o trošku (uloženome). Vrijednost postignuća povezuje se s time koliko je zadatak važan nekom pojedincu dok se intrinzično zanimanje odnosi na zadovoljstvo izazvano aktivnim sudjelovanjem u zadatku. Korisnost zadatka za buduće planove pojedinca smatra se korisnom vrijednošću, a percepcija pojedinca o negativnim troškovima koji se povezuju sa zadatkom naziva se uvjerenjem o trošku. Te četiri komponente zajednički funkcioniraju i čine vrijednost koju pojedinac pripisuje zadatku (Wigfield i Eccles, 1992, citirano u Pintrich i Schunk, 2002). Istraživanja pokazuju da se vrijednost zadatka pozitivno povezuje sa postignućem (npr. Yumusak, Sungur i Cakiroglu, 2007). Još jedna komponenta uvjerenja o motivaciji jest usmjerenost ka cilju. Ta se usmjerenost odnosi na učenikove razloge ili namjere za određeno ponašanje tijekom postignuća (Ames, 1992; Dweck, 1986; Nicholls, 1984). Dva su glavna usmjerenja ka cilju, dobro znanje i izvedba (Ames, 1992). Učenici koji teže vladati nekim predmetom vrednuju samo učenje i zabrinuti su za unapređenje vlastite kompetencije. Ako su uvjereni da će im marljiv rad donijeti uspjeh, vjerojatnije je da će ustrajati na aktivnostima učenja (Ames, 1992; Meece, Blumenfeld i Hoyle, 1988). Međutim, učenici kojima je izvedba prihvaćeni cilj smatraju da je učenje način na koji će pokazati drugima svoje sposobnosti (Ames, 1992; Ames i Archer, 1988; Meece, Blumenfeld i Hoyle, 1988). Rezultati istraživanja uglavnom otkrivaju da učenici kojima

je cilj dobro znanje više pokazuju oblike ponašanja kao što su veći kognitivni angažman, akademska učinkovitost, samoregulirano učenje i slabije ponašanje koje izaziva prekide i dezorganiziranost (Anderman i Maehr, 1994; Elliot i Harackiewicz, 1996; Kaplan, Gheen i Midgley, 2002; Maehr i Midgley, 1991; Middleton i Midgley, 1997).

Faza izvedbe pri samoregulaciji sastoji se od kontrole nad samim sobom i vlastitoga promatranja. Kod samokontrole učenik se koristi strategijama koje su odabrane u fazi prethodnoga razmišljanja. Samokontrola obuhvaća procese samoučenja (kada osoba objašnjava kako obaviti neki zadatak dok isti obavlja), zamišljanja (kada se konstruiraju mentalne slike) i usmjeravanja pažnje (kada se poboljšava koncentracija) te strategije povezane sa zadatkom (kada se bavi potrebnim dijelovima zadatka). Samopromatranje – druga komponenta u fazi izvedbe – obuhvaća vlastito praćenje i eksperimentiranje. Pravodobna povratna informaciju koju osoba daje sama sebi služi za poduzimanje korektivnih koraka. S druge strane, netočna samopromatranja kao ona kada osoba krivo sagledava ili iskrivljuje aktivnosti ne pridonose korekcijama. Kada pojedinci dobiju dijagnostičku informaciju o svojim aktivnostima mogu sustavno mijenjati načine funkcioniranja i sudjelovanja u osobnim eksperimentima (Zimmerman, 2005).

Treću fazu – samorefleksiju – čine vlastita prosudba i vlastita reakcija. Samoprocjena se odnosi na to da osoba sama vrednuje izvedbu i povezuje ju s odgovarajućim posljedicama. Pojedinci uspoređuju informacije do kojih dolaze samopromatranjem s nekim kriterijima koji bi mogli biti izvrsnost, prethodna izvedba, normativni ili kolaborativni. Samoprocjena pojedinaca povezuje se s posljedičnim atributima kao što su rezultati njihovih aktivnosti, primjerice kada se loša izvedba pripisuje nedostatku napora ili slaboj sposobnosti. Pripisati neuspjeh uporabi specifične strategije tako navodi pojedinca na to da usvoji nečiju strategiju. Budući da se strategije mogu korigirati, ta atribucija služi održanju motivacije i zaštiti od negativnih reakcija. Samoreakcija obuhvaća samozadovoljstvo i prilagodljivo zaključivanje. Samozadovoljstvo je važno jer pojedinci slijede aktivnosti koje stvaraju zadovoljstvo. Prilagodljivi zaključci su u vezi s načinima na koje će pojedinci tumačiti kako će poduzeti korake da bi regulirali naredne aktivnosti, a prilagodljivi ih zaključci vode ka potencijalno boljim oblicima samoregulacije kao što je prilagođavanje strategija (Zimmerman, 2005). No defenzivni zaključci, nazvani samohendikepirajućim strategijama, potkopavaju uspješnu prilagodbu. Covington (1992) opisuje samohendikep kao „stvaranje određene prepreke za nečiju izvedbu – imaginarne ili realne – tako da osoba ima spremno opravdanje za potencijalni neuspjeh" (str. 85). Samohendikepirajuće strategije mogu biti odgađanje (odgoditi neki zadatak navodeći neracionalne razloge), postavljanje nedostižnih ciljeva i odbijanje zadatka umanjujući njegovu važnost. Iako se time postiže privremeno olakšanje, samohendikepirajuće strategije najvjerojatnije će potkopati učenikovu izvedbu (Covington, 1992). Istraživanje pokazuje da se samohendikep povezuje sa slabim uspjehom, pojačanim povlačenjem i lošim navikama učenja (Midgley i Urdan, 1995; Urdan i Midgley, 2001). Samorefleksije učenika o događajima utječu na sljedeću fazu promišljanja i tako stvaraju ciklični proces (Zimmerman, 2005).

Zašto treba težiti samoreguliranom učenju u školama?

TIMSS (Treće međunarodno istraživanje matematike i prirodnih znanosti) i PISA (Program za međunarodno vrednovanje učenika) pokazali su da je uspjeh učenika na području prirodnih znanosti daleko ispod očekivane razine. Štoviše, istraživanje je ukazalo na to da motivacija učenika za znanost opada s njihovim godinama (Guvercin, 2008; Pell i Jarvis, 2001; Senler i Sungur, 2009). Borkowski i Thorpe (1994) tvrde da nedostaci na planu samoregulacije mogu biti razlogom slabijih postignuća jer oni sa lošijim rezultatima manje točno vrednuju svoje sposobnosti, postavljaju niže akademske ciljeve, više se koncentriraju na negativne vidove aktivnosti i više su samokritični, manje su učinkoviti po pitanju vlastite realizacije te ne ustrajavaju na aktivnostima učenja za razliku od onih uspješnih. Suprotno tomu, učenici koji sami sebe reguliraju učinkovito si postavljaju ciljeve, biraju strategije i njima se koriste radi postizanja svojih ciljeva te nadgledaju rezultate vlastitih aktivnosti. Oni su učinkoviti sami po sebi, predani stjecanju potrebnoga znanja i vještina te spremniji tražiti društvenu pomoć kada im je potrebna (Risemberg i Zimmerman, 1992; Zimmerman i Martinez-Pons, 1988). Vrlo uspješni učenici koriste se strategijama samoregulacije učinkovitije od slabo uspješnih učenika (Risemberg i Zimmerman, 1992; Zimmerman i Martinez-Pons, 1990).

Zahvaljujući svojim snažnim osobinama, učenik koji sam sebe regulira privlači pozornost psihologa koji se bave obrazovanjem kao i onih koji donose važeće propise (Boekaerts, 1999). Wolters (2003) opisuje samoregulirane učenike kao „... autonomne, refleksivne i efikasne učenike koji raspolažu kognitivnim i metakognitivnim sposobnostima te motivacijskim uvjerenjima i stajalištima potrebnim za razumijevanje, nadgledanje i usmjeravanje vlastitog učenja" (str. 189). Da bi regulirali učenje, takvi se učenici koriste nizom kognitivnih (ponavljanje, razrada, organizacija), metakognitivnih (planiranje, nadzor, regulacija) i strategija upravljanja resursima (Pintrich, 1999). Raspolažu znanjem o vještini, ponašanju i samomotivaciji te kako to znanje učinkovito primijeniti. Svjesni svojih prednosti i nedostataka, učenici koji sami sebe reguliraju selektivno primjenjuju strategije da bi osobno ostvarili ciljeve. Nadgledaju svoje postupke i ponašaju se samorefleksivno. Ako napreduju ka vlastitim ciljevima, to im povećava samozadovoljstvo i motivaciju (Zimmerman, 2002); ako ne napreduju, možda moraju mijenjati strategije (Horner i Shwery, 2002). Dobri učenici koji sami sebe reguliraju zapravo *aktivno* upravljaju svojom spoznajom, osjećajima i ponašanjem tako da se kreću ka vlastitim ciljevima (Schunk & Zimmerman, 2008; Wolters, 2003). Taj aktivni angažman u njihovu procesu učenja čini samoregulirano učenje kritičnim čimbenikom (Patrick i Middleton, 2002). Unapređujući svoje vještine, samoregulirani učenici mogu učinkovito odgovarati na zahtjeve dinamične okoline (Zimmerman i Schunk, 2001). Oni razvijaju znanja, vještine i stajališta koja su prenosiva iz jednog konteksta učenja u drugi, u školi i izvan nje (Boekaerts, 1999). Stoga se smatra da samoregulirano učenje osnažuje cjeloživotno učenje pojedinca (Schraw, Crippen i Hartley, 2006; Zimmerman, 2002).

Iako bi jedan od glavnih ciljeva obrazovanja trebao biti razvijanje vještina samoregulacije (Boekaerts, 1997; Puustinen i Pulkkinen, 2001; Schraw, Crippen i Hartley, 2006), mali broj učitelja podržava samoregulaciju učenika u svojim razredima (Randi i Corno, 2005; Zimmerman, 2002). Učitelji rijetko potiču učenike na postavljanje ciljeva, rijetko im pružaju mogućnosti za odabir akademskih zadataka ili ih rijetko navode na to da sami vrednuju svoj rad (Zimmerman, 2002). Potrebno je, dakle, utvrditi nastavne pristupe koji će promovirati samoregulaciju kod učenika: samoregulacija će se vjerojatno više razvijati kada se učenike potiče na autonomiju, kada je zadatak motivirajući, a povezanost između truda i uspjeha isticana u nastavnoj sredini (Paris i Paris, 2001; Sungur i Gungoren, 2009). Tradicionalni pristupi koji podrazumijevaju učenikovo pasivno usvajanje znanja i vještina od učitelja (Boekaerts, 1997) ne odgovaraju potrebama za znanjem, teorijom i praksom koji se brzo mijenjaju. Naprotiv, suvremeni pristupi stavljaju učenike u situaciju koja od njih zahtijeva da konstruiraju vlastito znanje (Savery, 2006). Učenje rješavanjem problema, jedan od suvremenih pristupa čiji su teorijski korijeni u konstruktivizmu, može unaprijediti samoregulaciju kod učenika. Daje učenicima odgovornost za njihovo učenje tako da im pruža nadzor nad onim što uče i kako uče (Paris i Paris, 2001). U nastavku rada opisujemo učenje rješenjem problema i objašnjavamo kako ono može promovirati samoregulaciju kod učenika. Zatim dajemo pregled istraživanja o učincima takvog učenja u K12-znanosti. Cilj ovoga istraživanja je nadasve pružiti empirijski dokaz, na temelju literature, o učinkovitosti učenja rješenjem problema na razvoj učeničke samoregulacije.

Učenje rješenjem problema

Učenje rješenjem problema je prvo nastalo za potrebe učenika medicinskih škola krajem 1960-tih, a zbog svojih se prednosti primjenjivalo u visokim, srednjim i osnovnim školama (Evenson i Hmelo, 2000). Savery (2006) definira učenje rješenjem problema kao „nastavni pristup koji učeniku kao središnjoj osobi daje ovlasti da provodi istraživanje, povezuje teoriju i praksu te primjenjuje znanja i vještine na stvaranje održivog rješenja za neki postavljeni problem" (str. 12). Učenje rješenjem problema je pristup usredotočen na učenike; učenici uvode neki problem na temelju kojega provode istraživanje. Problemi su, nerijetko interdisciplinarni, nestrukturirani (složeni i bez jednostavnih odgovora), zanimljivi i autentični (Barell, 2007). Zadatak koji treba riješiti uglavnom je povezan s nekim stvarnim problemom (Kain, 2003). U početku učenici nemaju informaciju o rješenju problema, već ga počinju razumijevati dok se njime bave; određuju ono što im je već poznato i ono što im je potrebno znati kako bi došli do nekoga rješenja (Stepien i Gallagher, 1993). Učitelj ima ulogu pomoći učenicima kako postaviti pitanja i gdje potražiti informaciju. Na kraju učenici predlažu neko rješenje. Učenje rješenjem problema omogućuje učenicima razvoj niza vještina; učenici međusobno surađuju na rješenju problema, razvijaju vještine kritičkoga mišljenja, uče kako primjenjivati znanje i povezivati ga sa svakodnevnim životnim

iskustvom. Od njih se očekuje da primjenjuju to znanje i pokazuju metakognitivne vještine kao što je nadzirati vlastito razumijevanje. Postaju odgovorni za svoje učenje i pretvaraju se u učenike usmjerene same na sebe (Kain, 2003; Savery i Duffy, 1995).

Postoji uvjerenje da specifičnost učenja rješenjem problema donekle čini samoregulirano učenje lakšim. Na samom početku učenici su suočeni s realnim problemom koji je njima osobno važan. Nastoje se više angažirati oko nekog stvarnog problema koji im je poznat (Savery & Duffy, 1995) jer ih problemi iz realnoga svijeta *motiviraju* da rade na konceptima i načelima koje trebaju poznavati da bi riješili taj problem (Duch, Groh i Allen, 2001). Vjeruje se tako da je učenicima angažman na stvarnim problemima poticajan i zanimljiv te da pojačava njihovu *intrinzičnu vrijednost* kada je učenje u pitanju (Loyens, Magda i Rikers, 2008). Učitelj čija je uloga olakšati im zadatak izbjegava davati informacije, ali postavlja pitanja da bi aktivirao njihovo znanje (Savery i Duffy, 1995). Pitajući ih, primjerice, što znate o tom problemu, učitelj nastoji učenike upoznati s metakognitivnim pitanjima (Stepien i Gallagher, 1993). Dok analiziraju problem, učenici određuju bitne činjenice o problemu te postavljaju hipoteze o mogućim rješenjima. Određuju također bitne nedostatke u svome znanju, a onda kreću u daljnju potragu polazeći od tih istih nedostataka (Hmelo-Siver, 2004). Pri analizi složenih problema i traženju rješenja uključeni su u *kritičko mišljenje* (Duch, Groh i Allen, 2001). Kako vrijeme prolazi stječu iskustvo *vrednovanja* onoga što znaju, određuju ono što trebaju znati i koriste se odgovarajućim izvorima (Duch, Groh i Allen, 2001; Stepien i Gallagher, 1993). Prikupljaju podatke i zajedno vrednuju pretpostavke donesene na temelju prikupljenih podataka (Stepien i Gallagher, 1993). Vrednovanje je važno pitanje jer promiče *planiranje* i *reguliranje* budućih nastojanja (Zimmerman, 2005). Nakon vrednovanja novoga znanja, ako odluče da im nije dostatno za rješenje problema, formuliraju nova pitanja na kojima nastavljaju raditi. U međuvremenu razmatraju (*refleksija*) aktivnosti koje su proveli (Hmelo i Lin, 2000). Refleksija i evaluacija njihova rada pridonose osjećaju upravljanja vlastitim učenjem i odgovornosti za njega (Paris i Paris, 2001). Usmjeravajući učenje tako što, primjerice, odlučuju koja im je informacija potrebna, učenici imaju glavnu odgovornost u učenju (Savoie i Hughes, 1994). Dajući odgovornost učenicima, učenje rješenjem problema i zahtijeva i podržava samoregulirano učenje (Paris i Paris, 2001). Timski rad omogućuje razvoj *interpersonalnih* i *komunikacijskih vještina,* pa učenici postaju dobri suradnici (Duch, Groh i Allen, 2001; Hmelo-Silver, 2004). Ono također zahtijeva od učenika da svojim proizvodom ili izvedbom pokažu što su naučili (Savoie i Hughes, 1994). Na kraju svakoga problema učenici tako *refleksivno razmatraju* znanje koje su usvojili. Ukratko, učenje rješenjem problema potiče motivaciju kod učenika tako što ih suočava s autentičnim problemskim situacijama koje su povezane s njihovim životima te im daje veće pravo vlasništva nad učenjem tako što donose odluku o potrebnom znanju ili izvorima koje treba istražiti (Savoie i Hughes, 1994; Paris i Paris, 2001). Učenje rješenjem problema promovira aktivno sudjelovanje učenika u nastavnome procesu kroz primjenu kognitivnih i metakognitivnih strategija učenja kao što su nadzor nad vlastitim učenjem; također podržava učeničku suradnju

u obliku timskoga rada (Savery i Duffy, 1995). Kroz procese učenja rješenjem problema učenici zapravo razvijaju vještine koje su suštinske za kontinuirano učenje (Duch, Groh i Allen, 2001). Ipak, ograničeni su istraživački dokazi o djelotvornosti učenja rješenjem problema na samoregulirano učenje. Glavni je cilj ovog istraživanja dati pregled empirijskih studija o učincima učenja rješenjem problema na razne aspekte samoregulirane nastave u slučaju K-12 znanosti te pružiti dokaze za tu učinkovitost na razvoj samoreguliranog učenja. Bit će navedena ograničenja u navedenom istraživačkom području kao i prijedlozi za buduća istraživanja.

Metode

Za potrebe ovog istraživanja napravljen je pregled dosadašnjih studija s primjenom učenja rješenjem problema na nastavu u sklopu K-12 znanosti i s ciljem utvrđivanja njezinih učinaka na samoregulaciju kod učenika. Literatura je istražena putem baza podataka Eric i Academic Search Complete, pri čemu su se različito kombinirale ključne riječi kao što su „učenje rješenjem problema", „samoregulacija", „motivacija", „strategija učenja" i „metakognicija", a pretraživanje se ograničilo na njihovo navođenje u sažetcima. Četiri su istraživanja zadovoljila postavljene kriterije. Zatim je dalje pretražena referentna literatura vezana uz ta istraživanja, a konzultiran je i stručnjak za područje učenja rješenjem problema i samoreguliranog učenja zbog pomoći oko bilo kakvog relevantnog istraživanja koje bi pak dovelo do još jednog istraživanja.

Rezultati

U navedenoj literaturi pronađeno je pet istraživanja koja su se bavila učinkovitošću učenja rješenjem problema na samoregulirano učenje u nastavi K-12 znanosti. Dva su bila kvalitativna, a tri kvantitativna istraživanja. Njihove glavne značajke i rezultati ukratko su navedeni u Tablici 1, o čemu će u nastavku rada biti više riječi.

Sage (1996) se bavio učinkovitošću učenja rješenjem problema u jednom istraživanju slučaja. U njemu su sudjelovala tri razreda (jedan kombiniran od učenika prvog i drugog razreda, jedan kombiniran od učenika trećeg i četvrtog razreda, jedan samo s učenicima osmog razreda) iz dvaju škola. Učenicima su postavljeni nestrukturirani problemi koje su zatim istraživali. Učitelji, koji su imali iskustva s PN, primjenjivali su KWL strategije (Što misliš da znaš? Što želiš saznati? Što si naučio?) te su pripremili materijal za daljnje istraživanje. Učenici su proveli niz eksperimenata i zabilježili rezultate. Imali su također prigodu postavljati pitanja stručnjaku koji ih je posjetio. Na koncu su predstavili svoja rješenja drugim učenicima. Podatke su dobili na temelju promatranja razredne situacije, polustrukturiranih intervjua, učeničkih radova prikupljenih tijekom stjecanja iskustva s PN i refleksija učitelja. Učenici su uglavnom izjavili da im se sviđaju postavljeni problemi. I učitelji su imali pozitivno mišljenje o problemskoj nastavi. Spomenuli su napredak kod svojih učenika u pogledu vještina na višim razinama, razmišljanja i rješenja problema, i to ne samo u smislu usvajanja ključnih koncepata već i onih koji su s tim povezani. Autor predlaže nastavak istraživanja o primjeni problemske nastave u osnovnim i srednjim školama.

Novijeg je datuma još jedno istraživanje slučaja što su ga proveli Chin i Chia (2006). Istraživali su kako učenici jednog devetog razreda (*N*= 39) rješavaju nestrukturirane probleme povezane s temom hrane i prehrane u biologiji. Što se tiče njihove sposobnosti i brzine, učenici su bili heterogeni. Skupine su odlučile o tome što će učiti a da je povezano sa zadanom temom. Nakon čitanja i raspravljanja, sami su odredili problem. Zatim su tragali za rješenjem i konačno predstavili rezultate. Kao izvori podataka korištene su projektne datoteke, dnevnički zapisi o refleksiji, zapažanja, audio i video zapisi rasprava u razredu te intervjui s učenicima. Utvrđeno je da mnogim učenicima nije bilo lako samostalno odrediti problem, već su ga mogli definirati tek nakon rasprave s prijateljima i članovima obitelji. Istraživači su predložili da učenici eventualno pregovaraju s ostalima izvan razreda u toj fazi utvrđivanja problema. Unatoč poteškoćama, većini učenika svidjelo se istraživanje tema koje su, pak, proizašle iz njihova osobnog zanimanja. Također je utvrđeno da nestrukturirani problem potiče učenike na postavljanje pitanja, a pitanja su vrlo bitna jer određuju ono što su učenici naučili i kako su to naučili. Učenici su tako bili poticani na istraživanje usmjereno ka njima samima. Da bi pomogli učenicima postavljati korisna pitanja, autori su predlagali učiteljima korištenje grafički ili drugačije organiziranih materijala kao što su potrebno je znati i mentalne mape. Učenici su analizirali problem, donosili odluku o tome što žele saznati, proučavali izvore različitih podataka kao što su knjige, Internet, ankete i intervjui, refleksivno pristupali svojim pronalascima i kritički vrednovali rezultate. Imali su, štoviše, mogućnost interdisciplinarnoga pristupa zbog nestrukturirane prirode problema. Ovo je istraživanje na taj način potvrdilo primjenu nestrukturiranih problema u učenju rješenjem problema.

Tablica 1.

U jednom kvantitativnom istraživanju u kojemu je korištena statična usporedba skupina, Sungur i Tekkaya (2006) istraživali su efikasnost učenja rješenjem problema na motivaciju i uporabu strategija učenja koje su učenici desetog razreda sami navodili u slučaju nastavne jedinice o sustavu za izlučivanje. Korištena su dva kompletna razreda; jedan razred (*N*= 30, *prosječna dob*= 16.0 godina) nasumično pripisan eksperimentalnoj, a drugi (*N*= 31, *prosječna dob*= 16.6 godina) kontrolnoj skupini. Sudjelovalo je 39 muških i 22 ženska ispitanika. Kontrolna skupina poučavana je tradicionalno, dok je eksperimentalna skupina imala problemsku nastavu u trajanju od šest tjedana. Učenici iz eksperimentalne skupine radili su u malim skupinama, heterogenim po stilu učenja, akademskom uspjehu i rodu ispitanika. Postavljen im je nestrukturirani problem o slučaju jednoga pacijenta. Raspravljali su o problemu, utvrđivali činjenice, predviđali i odlučivali o tome koja im je informacija potrebna. Zatim su zaključivali koje izvore koristiti da bi došli do informacije (knjige, Internet, stručnjake). Nakon što su došli do informacije, međusobno su unutar skupine podijelili podatke koje su prikupili. Razmatrali su svoje prijašnje ideje u skladu s novom informacijom te dolazili do novih pitanja. Taj se proces nastavljao sve dok nisu povjerovali da imaju dovoljno informacija. Iako nije postojala razlika u rezultatima prethodnoga testiranja između eksperimentalne i kontrolne skupine,

provedena je MANOVA analiza na rezultatima poslije testa otkrila statistički značajnu razliku među njima u smislu nekih motivacijskih varijabli i varijabli uporabe strategija učenja. Pokazalo se, specifično govoreći, da su učenici iz eksperimentalne skupine postigli bolje rezultate od učenika iz kontrolne skupine na intrinzičnom usmjerenju ka cilju, vrednovanju zadatka, razradi, kritičkom mišljenju, metakognitivnoj samoregulaciji i zajedničkom učenju. Istraživači su zaključili da problemska nastava potiče vještine samoregulacije te predložili njezino uvrštenje u poučavanje znanstvenih predmeta.

Odnose između pojedinih kognitivnih i metakognitivnih varijabli u uvjetima učenja rješenjem problema istraživali su Araz i Sungur (2007). Četiri osma razreda u kompletnom sastavu (*N*= 126) iz jedne urbane srednje škole sudjelovala su u istraživanju, dok kontrolna skupina nije bila uključena. 60 muških i 66 ženskih osoba u dobi od 13 do 15 godina bili su sudionici istraživanja. Autori su istraživali odnose između sposobnosti zaključivanja, pristupa učenju (duboko-smisleno učenje i površno-učenje memoriranjem), prethodnoga znanja, motivacijskih varijabli i uspjeha u genetici kroz razvijanje i testiranje modela konceptualne staze. Analiza je pokazala da sposobnost razmišljanja, smisleno učenje i prethodno znanje imaju pozitivan izravni učinak na učenički uspjeh u genetici, dok uvjerenja o vrijednosti zadatka imaju negativan izravni učinak. Istraživači su potvrdili potrebu za mjerenjem vrijednosti zadatka kroz tri odvojene komponente kao što su vrijednost važnosti, vrijednost korisnosti i intrinzično zanimanje umjesto jedne zajedničke varijable sveukupne vrijednosti zadatka. Analiza je također pokazala da pristup učenju posreduje pri odnosu između sposobnosti zaključivanja i uspjeha, kao i odnosa između vrijednosti zadatka i uspjeha. Utvrđeno je da kognitivne varijable bolje predviđaju uspjeh nego motivacijske varijable jer objašnjavaju veću proporciju varijance u uspjehu Sveukupno, 23% varijance u uspjehu otpada na njezin odnos s pristupom učenju, prethodnim znanjem, uvjerenjima o vrijednosti zadatka i sposobnošću zaključivanja.

U jednom drugom istraživanju provedenom u Turskoj, Demirel i Arslan Turan (2010) istraživali su učinkovitost učenja rješenjem problema na stajališta učenika šestih razreda o znanosti, metakognitivnu svjesnost i motivaciju na primjeru nastavne jedinice o našem tjelesnom sustavu. Dva su kompletna razreda iz jedne privatne škole nasumično pripisana eksperimentalnoj (*N*= 23) i kontrolnoj skupini (*N*= 19). 23 dječaka i 19 djevojčica sudjelovalo je u ovom istraživanju. Usporedbom prije testiranja utvrđeno je da su skupine vrlo slične jedna drugoj u smislu uspjeha, stajališta, metakognitivne svjesnosti i motivacijske razine. Kontrolnu skupinu su poučavali prema načelima koja je propisalo Ministarstvo obrazovanja, dok je eksperimentalna skupina bila podvrgnuta problemskoj nastavi. Istraživanje je trajalo 8 tjedana. Učenicima eksperimentalne skupine predstavljena su tri problemska scenarija. Kroz istraživanje ih je vodio nastavnik iz predmeta Znanost i tehnologija. Učenici su raspravljali o problemu i stvarali pretpostavke. Nastavnik ih je pitao koje su im informacije potrebne da bi riješili problem, a oni su napravili popis onoga što trebaju naučiti. Koristili su se knjižnicom i računalnim laboratorijem za pretragu i razmjenu svojih otkrića unutar skupine. Polazeći od pretrage i rasprava, kreirali

su rješenja. Na kraju intervencije provedeno je testiranje. t-testovi neovisnih uzoraka pokazali su kod učenika koje su poučavali problemskim pristupom statistički značajnu razliku u korist stajališta o znanosti, metakognitivne svjesnosti i motivacije za znanost. Autori su potvrdili da učenje rješenjem problema omogućuje učenicima pozitivne uvjete za suradnju i daje im prigodu da uče o temama koje njih zanimaju. Međutim, zbog malog istraživačkog uzorka, nije moguće primijeniti veću generalizaciju, pa istraživači ističu potrebu za istraživanjem učinkovitosti učenja rješenjem problema na većim uzorcima ispitanika.

Zaključak

Gore navedena istraživanja pružaju empirijski dokaz o tome da učenje rješenjem problema potencijalno podržava razne vidove učeničke samoregulacije u znanosti. Specifično govoreći, ona otkrivaju da okolina u kojoj se provodi učenje rješenjem problema daje učenicima prigodu istraživati njima zanimljive teme koje ih motiviraju; učenici rade u skupinama i stupaju u interakciju sa svojim prijateljima; istražuju višestruke izvore podataka; usvajaju mnogo više od ključnih koncepata zbog nestrukturirane prirode problema (Sage, 1996; Chin i Chia, 2006). Štoviše, njihova uporaba kognitivnih strategija, motivacija, metakognitivna svjesnost i stajalište o znanosti unapređuju se u sredini u kojoj se primjenjuje učenje rješenjem problema (Sungur i Tekkaya, 2006; Demirel i Arslan Turan, 2010). Ti rezultati podržavaju učinkovitost učenja rješenjem problema kada je riječ o razvoju učeničke samoregulacije. Doista, u svome su istraživanju Cakir i Tekkaya (1999) predložili primjenu takvoga učenja u nastavi o znanstvenim sadržajima. Potvrdili su da ono učenicima pruža izazov za učenjem dok se bave stvarnim problemima, što potiče njihovo zanimanje za znanost, pomaže im usavršiti vještine potrebne za rješenje problema, poučava ih kako interdisciplinarno pristupati znanstvenim istraživanjima i međusobno surađivati. Autori jasno ističu potrebu za usvajanjem kurikula i nastave u području znanosti prema načelima učenja rješenjem problema. Mi smo također uvjereni da okolina u kojoj se takvo učenje provodi može pomoći učenicima da izgrade vlastito znanje te im dati prigodu da nauče kako rješavati probleme jer će na njih nailaziti u stvarnome životu. Pojedinci trebaju dobro regulirati svoju spoznaju, motivaciju i ponašanje da bi mogli učinkovito upravljati izazovima u životu, a – na temelju istražene literature -– može se potvrditi da sredina u kojoj se primjenjuje učenje rješenjem problema odgovara učenicama za razvoj vještina samoregulacije.

Preporuke za buduća istraživanja učinkovitosti učenja rješenjem problema na samoregulaciju

Polazeći od pregleda literature, čini se da postoje neka ograničenja u području istraživanja učinka što ga učenje rješenjem problema ima na učeničku samoregulaciju. S ciljem usavršavanja istraživanja u navedenom području, navodimo nekoliko preporuka:

1. U eksperimentalnim istraživanjima ispitanici se uglavnom nisu nasumično pripisivali skupinama. Ta su istraživanja obuhvaćala kompletne razrede, ali su neka od njih utvrđivala postojanje prethodnih razlika među skupinama. Ako nasumični odabir nije moguć, što dokazuje jednakost između eksperimentalne i kontrolne skupine, odobravaju se postupci kojima će se izjednačiti skupine na početku istraživanja.
2. Istraživači su nastojali izvješćivati samo o statistički značajnim razlikama kada je riječ o rezultatima njihovih testova; međutim, praktična važnost je također bitna za smislena tumačenja magnitude razlika u kvantitativnim istraživanjima. Potičemo stoga autore da navode vrijednosti veličine učinka te na njihovu usporedbu s rezultatima prethodnih istraživanja.
3. Većina istraživanja bavila se temama iz biologije, ali su teme iz fizike i kemije također opravdane u istraživanju tako da se o učinkovitosti učenja rješenjem problema može raspravljati u širem rasponu tema. Strategije samoregulacije kojima se koriste pojedinci povezane su s domenom u kojoj se koriste jer domena donekle određuje funkcionalnije strategije. Potrebno je istražiti mogu li se strategije samoregulacije prenijeti i/ili jesu li potrebne neke izmjene da bi se mogle učinkovito koristiti u različitim domenama (Zeidner, Boekaerts i Pintrich, 2005).
4. Istraživači su se uglavnom usredotočili na fazu promišljanja u ciklusu samoregulacije kao što su postavljanje ciljeva i intrinzično zanimanje ili vrijednost. Međutim, mogu također istraživati vidove faza izvedbe i samorefleksije. Nedavno konstruirana online mjerenja uz pomoć dnevnika, verbalnih protokola, strukturiranih dnevnika, promatranja i mikroanalitičkih parametara mogu im omogućiti istraživanje samoregulacije u realnom vremenu te im pružiti informaciju o promjenama i kretanjima kada je riječ o učeničkoj samoregulaciji (opširniji pregled vidi u Zimmerman, 2008).
5. Pitamo se može li postojati bilo kakva sposobnost-tretman interakcija kada je riječ o učinku učenja rješenjem problema na samoregulaciju, odnosno različiti učenici mogu biti pod različitim utjecajem učenja rješenjem problema. Koran i Koran (1984) naglašavaju prethodno iskustvo učenja, opću sposobnost, anksioznost i motivaciju za uspjehom kao potencijalno prikladne za istraživanje obrazovanja u području znanosti. Je li učenje rješenjem problema jednako učinkovito kod učenika s različitim osobinama ili jesu li, ovisno o nekim značajkama, potrebne stanovite izmjene u problemskoj nastavi, kao što su varijacije u potpori, zaslužuje istraživanje.

Ograničenja opisanog istraživanja

U ovom istraživanju naveden je pregled empirijskih istraživanja učinkovitosti što ga učenje rješenjem problema ima na samoregulaciju na razini K-12. Rezultati možda nisu primjenjivi na ostalim razinama. Osim toga, oni možda pokazuju varijaciju ovisno o nekim učeničkim značajkama kao što su osobnost i sposobnost. Budući da

je dostupna literatura ograničena, nije bilo moguće istražiti eventualne razlike toga tipa u ovome istraživanju. Ono, štoviše, ne može baciti svjetlo na to razlikuje li se učinkovitost što ga učenje rješenjem problema ima na samoregulaciju po domenama (npr. fizika, znanosti o životu, društvene znanosti ili jezik) jer je broj istraživanja ograničen.