Journal of Turkish Science Education, Year, *Volume*(Issue), 461-476.
DOI no: 10.36681/tused.2021.84

Journal of Turkish Science Education
http://www.tused.org
© ISSN: 1304-6020

Metacognitive Skills and Self-Regulated Learning in Prospective Chemistry Teachers: Role of Metacognitive Skill-Based Teaching Materials

Utiya Azizah[1], Harun Nasrudin[2]

[1]*Dr., Chemistry Department, Faculty of Mathematics and Natural Sciences, Universitas Negeri Surabaya, Surabaya 60231, Indonesia. Email: utiyaazizah@unesa.ac.id*
https://orcid.org/0000-0002-2067-3435
[2]*Dr., Chemistry Department, Faculty of Mathematics and Natural Sciences, Universitas Negeri Surabaya, Surabaya 60231, Indonesia. Email: harunnasrudin@unesa.ac.id*
https://orcid.org/0000-0002-4315-876X

ABSTRACT
This study reports an empirical research of metacognitive skills and self-regulated learning of prospective chemistry teachers through the implementation of metacognitive skill-based teaching materials. This research involved 73 prospective chemistry teachers from Universitas Negeri Surabaya, Indonesia, who were studying solution chemistry matter. The metacognitive skills of prospective chemistry teachers were obtained by the essay tests, in accordance with indicators of metacognitive skills and questionnaires to measure prospective chemistry teacher' self-regulated learning. The data analysis use percentage, n-gain, mean, standard deviation, and simple correlation Pearson Product Moment. The results showed that (1) the majority of prospective chemistry teachers had metacognitive skills and self-regulated learning in "high" and "very high," category of and (2) a positive and significant correlation between metacognitive skills and self-regulated learning. In summary, the implementation of metacognitive-based teaching materials improved the metacognitive skills, build self-regulated learning, and metacognitive skills have a significant correlation on self-regulated learning with positive correlation.

ARTICLE INFORMATION
Received:
23.12.2019
Accepted:
23.05.2021

KEYWORDS:
Metacognitive skills, self-regulated learning, metacognitive-based teaching materials.

Introduction

Chemistry is a branch of science that studies the nature, structure, change, laws, and principles that describes the changes, concepts, and theories that interpret these things (Effendy, 2006). One of the important topics in chemistry is solution chemistry. The fundamental concepts in solution chemistry are colligative properties of solutions, the equilibrium of acid-base solutions, pH, hydrolysis, buffer solutions, and titration. Those concepts are usually taught in both basic chemistry in the first year and analytical chemistry in the third year to prospective chemistry teachers. However, various research findings have expressed difficulties with concepts related to the concept of acids and bases (Chaiyapha et al., 2011; Metin, 2011) the concept of pH (Watters & Watters, 2006), and the concept of colligative properties (Pinarbasi, 2009) in prospective chemistry teachers and learners. This shows that chemistry learning that is usually carried out is still not optimally empowering learners' potential. This is partly due to the lack of empowerment in learners' thinking because the majority of the perception of chemistry learning is only memorizing the material (Sirhan, 2007).

The development of 21st century science requires prospective chemistry teachers and learners to be able to compete by developing knowledge and skills. Chemistry also has the main goal of acquiring an organized bunch of knowledge and skills in solving problems. Problem-solving is a complex cognitive activity involving number of processes and strategies (Funke, 2010). The problem-solving skills can be achieved if the solver has relevant knowledge and principles in mind (Cooper & Sandi-Urena, 2009). So, the success of prospective chemistry teachers and students in completing assignments is very dependent on their awareness of what they know and how to apply them. Awareness will encourage prospective chemistry teachers and learners to be sensitive and critical in controlling the learning progress that they have achieved and will always evaluate themselves regarding their strengths and limitations in achieving a certain understanding.

Individuals' knowledge to control their ability in arranging, monitoring, and re-examining their understanding and action in solving a problem is closely related to metacognitive skills. Metacognitive skills are an important goal and focus of education in Indonesia and even the world lately (Asyari, 2016; Bakırcı & Çepni, 2016) which are simply defined as thinking about own thinking of individuals (Jaleel & Premachandran, 2016). Metacognition is one of the innovative skills in 21st century learning and high-level cognition processes that include thinking about knowledge and how to gain that knowledge through a reflective process. In line with that opinion, Thomas (2012) believed that metacognition is the key to following developments in 21st century science education. Garrett et al. (2007) reported that the integration of metacognitive skills in learning chemistry will encourage students to explicitly carry out learning activities that have been previously designed, evaluate their understanding, decide on the learning process, and determine the ease of learning to improve their learning outcomes.

Metacognitive skills are one of the most important pedagogical skills in teacher preparation and professional development programs to ensure that prospective chemistry teachers do the right learning activities in the classroom. Prospective chemistry teachers are expected to continue and realize the goals of national education, namely the intellectual life of the nation's children. Prospective chemistry teachers who have good metacognitive skills can not only be successful in academy, but they are also believed to be able to facilitate their future students in learning well (Jiang et al., 2016; Zhao et al., 2014). In addition, future students with good metacognitive skills can only be raised by prospective chemistry teachers with good metacognitive skills (Demirel et al., 2015). However, the results of the previous study indicated that science teachers still have weak pedagogical practices and it is necessary to enhance teachers' skills in active teaching (Bawaneh, 2019).

To sum up, those metacognitive skills are a process. In other words, it is a continuous activity and not an activity that only occurs for a moment, requiring learning efforts and exercises. Metacognitive skills can be an interest generator by using cognitive processes to reflect on self-cognitive processes. Metacognitive skills are very important because knowledge about cognitive processes can guide prospective chemistry teachers in developing and choosing strategies to improve their own performance. Metacognitive skills consist of planning, monitoring, evaluation (Hacker et al., 2009). Thus, it can work together to shape prospective chemistry teachers into self-regulated learners.

Every teacher should have self-regulated learning. It is an active and constructive process in which a person is capable to set goals for their learning and then try to monitor, regulate, and control their cognition, motivation, and behavior, guided and limited by goals and their contextual features in the environment (Boekaerts et al., 2000). Self-regulated learning is a learning activity carried out by a person with his freedom in determining and managing his teaching materials, time, place, and utilizing the necessary learning resources (Rajabi, 2012). Every person who commits to continue to higher education is required to study more independently and not only rely on what thought in the class (Santrock, 2002). In fact, quite number of prospective chemistry teachers have difficulty in fulfilling the higher education requirements, including un-regulated self-learning to finish lecture assignments (Hassel & Ridout, 2018). Peng (2012) also found that learning process in higher education requires self-regulated learning process which give more emphasizes to action rather than thinking. This condition occurs because prospective chemistry teachers are lack of the skills in how to understand thinking skills and thought processes. This resulted in the occurrence of instant learning so that in the long run, the learning process becomes less meaningful.

In addition, prospective chemistry teachers should be capable to work on class assignments that require planning and time management (Adebayo, 2015). This situation is in accordance with the learning process standard in higher education which has several characteristics, such that the learning achievements of graduates are achieved through a learning process that (a) adjust to the demands of the ability to solve problems in the realm of their expertise, (b) concern with the internalization of material properly and correctly, and (c) prioritize the development of independence in seeking and finding knowledge (Ministry of Research, Technology and Higher Education Regulation, 2015). This situation is strengthened by learning in the 21st century which must develop a vision of educating by implementing independent character through a program of strengthening character education (Presidential Regulation, 2017).

In summary, a person who has high self-regulated learning can manage their learning activities beginning from the preparation, implementation, and evaluation stages. This is in line with the research results that prospective chemistry teachers are required to have self-regulated learning, design their own learning in accordance with the learning objectives, select strategies and implement learning plans, monitor learning progress, and evaluate learning outcomes and compare with certain standards (Kuiper, 2002).

Metacognitive Skills

Metacognitive skills are the skills to process thinking including planning, monitoring, and evaluation skills. (Hacker et al., 2009). Metacognitive skills are required for pre-service teachers to understand how the task was carried out (Rivers, 2001). Therefore, it is very necessary for solving problems or assignments. A learning concept strengthening the metacognitive skills focuses on how prospective chemistry teachers participate in designing what they want to learn, monitoring the progress of their learning outcomes, and assessing what they have learned in solving problems. This is in accordance with the keywords of work ability in the description of the Indonesian Qualification Framework level 6 (undergraduate program) which are to apply, study, make designs, utilize science and technology, and solve problems (Ministry of Education and Culture, 2014).

Metacognitive skills in learning chemistry are needed to solve chemical problems (Kipnis & Hofstein, 2007). Cohors-Fresenborg and Kaune (2007) summarized the components of metacognitive skills into 3 activities which are carried out in problem solving consisting of (1) Planning Process. In this process, prospective chemistry teachers are required to predict what will be studied, how the problem will be mastered and the impression of the problem being studied, and plan the right way to solve a problem; (2) Monitoring process. In this process, prospective chemistry teachers need to ask themselves with questions like "what do I do?", "What is the meaning of this problem?" and "How should I solve it?"; (3) Evaluation process. In this process, prospective chemistry teachers make a reflection to find out how knowledge has been mastered, and what actions or improvements must be taken. Based on expert opinions and the results of these studies (Cohors-Fresenborg & Kaune, 2007; Kipnis & Hofstein, 2007), metacognitive skills are such an essential part of the learning process. Metacognitive skills are the basic potential skills that needs to be developed in prospective chemistry teachers. Prospective chemistry teachers who have metacognitive skills are those who have the knowledge and control of their thinking and learning activities in solving problems and understanding the extent of their success in learning.

By using metacognitive skills, prospective chemistry teachers will be able to acknowledge their best learning process, determine appropriate learning methods according to their own abilities, solve problems in learning both related to the problems given by the instructor or problems that come up to the learning process, and understand the extent of success that has been achieved in learning (Cooper & Sandi-Urena, 2009; Rompayom et al., 2010).

Metacognitive-Based Teaching Materials at Solution Chemistry

Basic chemistry courses are held for all chemistry, biology, physics, and mathematics students at the Faculty of Mathematics and Natural Sciences, Universitas Negeri Surabaya. To meet the standards of the learning process, it is necessary to develop teaching materials, one of which is the solution material. In accordance with the characteristics of the Ministry of Research, Technology and Higher Education No. 44 (2015), the development of teaching materials will enable lecturers to easily present lecture materials. This is in accordance with the results of Nasrudin and Azizah's (2010) that the development of science teaching materials in junior high schools could improve the quality of learning. Consequently, the results are strengthened by Azizah and Nasrudin's (2018) that the implementation of teaching materials in the group investigation cooperative model could empower students' thinking abilities in mastering concept learning.

Metacognitive-based teaching materials are required. This is based on the opinion that the development of metacognitive skills is necessary for students in solving chemistry learning problems (Rickey & Stacy, 2000; Schraw, 2001). To improve the quality of basic chemistry learning at the Faculty of Mathematics and Natural Sciences, Surabaya State University, metacognitive-based teaching materials have been developed, consisting of lesson plans, worksheets, and metacognitive assessments. Teaching materials that have been developed and implemented in this study already have criteria both in construct validity, content validity, and in accordance with metacognitive skills, namely, planning skills, monitoring skills, and evaluation skills (Azizah & Nasrudin, 2016).

Self-Regulated Learning

Self-regulated learning is defined as the degree of metacognition, motivation, and behavior of individuals in the learning process undertaken to achieve learning goals (Zimmerman, 2008; Zimmerman & Martinez-Pons, 2001). According to Boekaerts and Cascallar (2006), self-regulated learning occurs if a person can control and direct their cognitive processes and motivation to achieve their learning goals. From the social-cognitive perspective that asserted by several experts (Boekaerts et al., 2000; Pintrich, 2000). There are three parts for the processes of self-management in learning independence and beliefs that get along with it, (1) forethought, which refers to the respective processes that will influence and the initial beliefs before learning, including task analysis and self-motivation beliefs; (2) performance or volitional control, which refers to the processes occur during learning that affect concentration and performance, including self-control and self-observation; and (3) self-reflection, which refers to the processes occur after learning and students' reactions to the learning experience, including self-judgment and self-reaction.

According to Santrock (2007), the potential within someone can be achieved by applying self-regulated learning, not depending on others. Prospective chemistry teachers can actively participate in determining what will be learned and how to learn it. Self-regulated learning can free up prospective chemistry teachers in describing their ideas, interests, and talents. The need for prospective chemistry teachers' self-regulated learning is supported by several researches (Boekarts et al., 2000; Moseki & Schulze, 2010). Moseki and Schulze (2010) found that a person who had independent learning was often high-achieving individuals. Likewise, Boekarts et al. (2000) stated that success in education is based on a person's level of independence.

Dependence of Self-Regulated Learning on Metacognitive Skills and Its Teaching Materials

Metacognitive skills play an important role in shaping self-regulated learning (Peter, 2000; Shannon, 2008). The teaching materials developed regarding metacognitive skill-based will lead individuals to have a good self-regulated learning. A self-regulated learner tends to learn better; can monitor, evaluate, and manage their learning effectively; save time in completing their work; organize learning and time efficiently; and obtain high scientific value (Hargis, 2000).

Referring to various data mentioned above, it is clear that there is a connection between metacognitive skills and self-regulated learning. Metacognitive skills and self-regulated learning in mastering concepts need to be developed by training from an early age. This internalized mindset will carry over to life in society. But unfortunately, not many studies have revealed that how the connection of metacognitive skills on the level of self-regulated learning of prospective chemistry teachers. This study aims to understand more deeply the profile of the metacognitive skills and self-regulated learning of prospective chemistry teachers through applying the metacognitive-based teaching materials in mastering concepts. Further, it revealed how the statistically correlation between metacognitive skills and self-regulated learning in understanding the concepts of solution chemistry use metacognitive skill-based teaching materials.

Methods

General Background of Research

This type of research was pre-experimental. Research testing was conducted using a one-group pretest-posttest design (Fraenkel & Wallen, 2009). Prior to the teaching intervention, pretests were administered to determine metacognitive skills and self-regulated learning of prospective chemistry teachers. Then, prospective chemistry teachers use metacognitive skill-based teaching materials at solution chemistry matter in the learning process with a pattern of learning problem solving activities through metacognitive skills include planning skills, monitoring skills, and evaluation skills. Finally, to reveal the profile of metacognitive skills and learning independence in mastering the concept, a posttest was given. Posttest is also used to determine the significance and direction of the relationship between two variables (metacognitive skills and self-regulated learning) by using the Pearson Product Moment method. The realization and implementation of metacognitive skill-based teaching materials in the lecture process used the lecture lesson plans, student worksheets, metacognitive skills tests, and self-regulated learning inventories.

Participants of Research

The target population of this study was all students in the 2018-2019 academic year at the Department of Chemistry, Universitas Negeri Surabaya, Indonesia. The samples of the study consisted of three parallel classes drawn from 73 prospective chemistry teachers who were studying solution chemistry in a basic chemistry course at the Department of Chemistry. The sample was selected by using the purposive sampling technique. This sample selection technique focused on the similarity of characteristics, namely prospective chemistry teachers in the first year who were studying solution chemistry in a basic chemistry course and has a relationship with the topic being studied.

Instrument and Procedures

The instruments used for metacognitive skills and self-regulated learning were essay tests and questionnaires, respectively. The instruments have been developed in previous studies, that was, metacognitive skill-based chemical concept mastery tests in the form of essays consisting of 12 items about solution chemistry matter arranged by indicators of metacognitive skills, namely, goal-setting (P1), identifying the known knowledge (P2), determining the learning strategies (P3), monitoring the relevance of existing knowledge to the used learning strategies (M1), monitoring the achievement of objectives in making conclusions (M2), and evaluating thought processes and outcomes (E). The metacognitive skills-based chemical concept mastery tests have been validated with results of the content and construct validity was shown to be very valid for all questions and had 0.88 reliability revealed in Cronbach's alpha (Azizah & Nasrudin, 2016). In addition, this study also used self-regulated learning (SRL) questionnaire with a 5-point Likert scale response format that had values ranging from those were very appropriate (5), appropriate (4), hesitant (3), not appropriate (2), and very inappropriate (1) on indicators of self-motivation belief, task analysis, self-control, self-observation, self-judgment, and self-reaction. The indicators respectively have been validated with results of the content and construct validity were shown to be very valid and had 0.93 reliability revealed in Cronbach's alpha (Azizah et al., 2014).

As already mentioned, this research was carried out in the Basic Chemistry Course, with the learning materials consisting of the colligative properties of solution, equilibrium of acid-base solutions, hydrolysis, common-ion effect, buffer solutions, solubility product constant, and titration. Classes were taught directly by researchers because the researchers are developers of metacognition-based teaching materials. So, they are able to implement these metacognition-based teaching materials better.

The pattern of learning activities in the classroom is carried out by applying metacognitive skills including planning skills, monitoring skills, and evaluation skills using metacognitive skills-based teaching materials with the following stages: (1) in planning skills, the lecturer presents problems/phenomena that are often encountered in everyday life which are presented at the beginning of the student worksheet. Furthermore, prospective chemistry teachers independently identify problems in phenomena using known knowledge, set goals, and determined learning strategies to solve problems, (2) in monitoring skills, prospective chemistry teachers discuss completing the task through practicum activities in the laboratory or using various learning resources in order to find the truth of a concept according to the problem/task given by the lecturer while monitoring the relevance of known knowledge with the learning strategies. Furthermore, presenting the results of the discussion in front of the class while monitoring the achievement of objectives in making conclusions, and (3) in the evaluation skills, prospective chemistry teachers conduct self-evaluation of the processes and results of thought that have been carried out.

Data Analysis

The data analysis technique used in this research was descriptive analysis. Qualitative descriptive analysis was used to form a description of information based on certain categories. On the other hand, quantitative descriptive analysis is the percentage, mean, standard deviation, used to determine the increase in metacognitive abilities using descriptive analysis techniques with N-Gain (Hake, 2002) between pretest and posttest on the metacognitive skills test.

The N-Gain formula refers to Hake (2002), which is:

$$(g) = \frac{\%\, actual\ gain}{\%\, potential\ gain} x\ 100 = \frac{\%\, posttestscore - \%\, pretestscore}{100 - \%\, pretestscore}$$

N-Gain analysis determines the category of improvement of student's metacognitive skills, categorized as follows: (1) "high gain" if $g > 0.7$, (2) "medium gain" if $0.3 < g \leq 0.7$, and (3) "low gain" if $g \leq 0.3$ (Hake, 2002).

To find out the student's SRL, a descriptive analysis technique was used with the grouping of SRL based on the calculation of the ideal mean and ideal standard deviation and categorized according to Arikunto (2006), namely, (1) very high ($X > M + 1.5$ SD), (2) high ($M + 0.5$ SD $< X < M + 1.5$ SD), (3) moderate ($M - 0.5$ SD $< X < M + 0.5$ SD), (4) low ($M - 1.5$ SD $< X < M - 0.5$ SD), and very low ($X < M - 1.5$ SD).

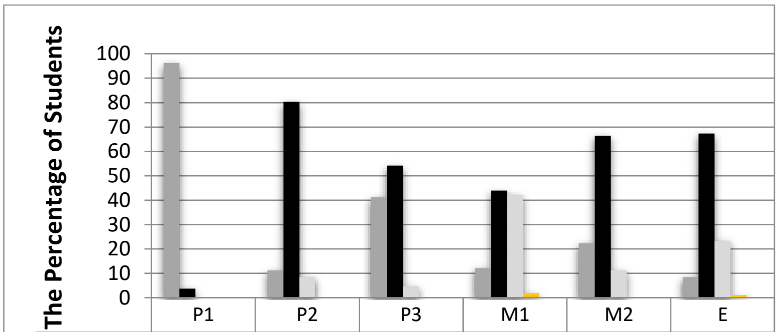
After the measurement for each item in the variable, the next step was to do hypothesis testing began with the prerequisite tests to find out the data was normally distributed. The normality test was carried out on variable metacognitive skills and variable self-regulated learning. The normality test used the Kolmogorov-Smirnov test with the criteria for a significance value of $p > 0.05$. So, the data were normally distributed. After making normality for each variable, the next step was analysis simple correlation Pearson Product Moment to test the presence/absence of a relationship and the direction of the relationship between two or more variables. The relationship between metacognitive skills and self-regulated learning of prospective chemistry teachers' at the use of metacognitive skills-based teaching materials was analyzed by using regression analysis.

Findings

The achievement of metacognitive skills indicators is presented by research data which showed that the most of the prospective chemistry teachers had metacognitive skills in the "high" and "very high" categories of all indicators (Figure 1). However, there were still some prospective chemistry teachers who had the skills under metacognitive category "medium" on indicators P2, P3, M1, M2, and E and "low" on indicators M1 and E.

Figure 1

Profile of metacognitive skills in solution chemistry



	P1	P2	P3	M1	M2	E
Very High	96,26	11,21	41,12	12,15	22,43	8,41
High	3,74	80,37	54,21	43,93	66,36	67,29
Medium	0,00	8,41	4,67	42,06	11,21	23,36
Low	0,00	0,00	0,00	1,87	0,00	0,93
Very Low	0,00	0,00	0,00	0,00	0,00	0,00

The results of this study are also supported by N-Gain results on all indicators of metacognitive skills in the "high" category, except for the M1 indicator with the "medium" category (Table 1). This means that learning activities can improve the indicators of metacognitive skills.

Table 1

The Average İnitial Tests, Final Tests, and N-Gain of Each Metacognitive Skills Test İndicator

Indicators	Average initial tests	Average final tests	N-Gain and criteria
P1	28.66	92.58	0.90 (High)
P2	25.00	78.32	0.71(High)
P3	21.24	82.84	0.78 (High)
M1	22.66	73.78	0.66 (Medium)
M2	19.24	78.87	0.74 (High)
E	13.66	74.90	0.71 (High)

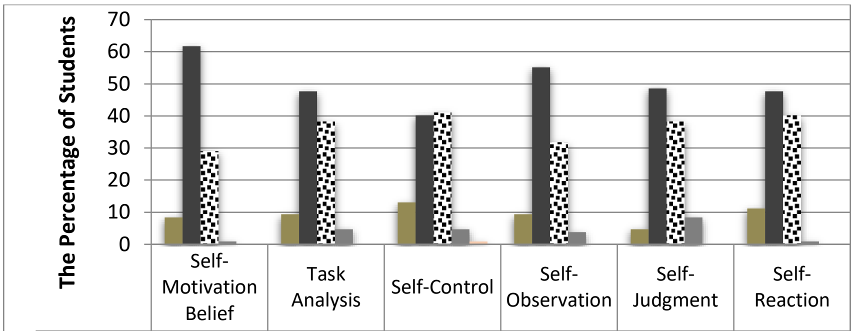
The results in Figure 1 shows that there were still a number of prospective chemistry teachers who had low ability in indicators of monitoring the relevance of the known knowledge to the learning strategies used and also evaluating teaching processes and outcomes.

Table 1 shows that the majority of prospective chemistry teachers had mastered the concept of solution chemistry matter and most of the indicators of metacognitive skills had high N-Gain, which means that prospective chemistry teachers has been able to improve metacognitive skills.

One of the most important findings of this study was the majority of prospective chemistry teachers already had high and very high SRL in the indicators of self-motivation belief, task analysis, self-observation, self-judgment, and self-reaction, as presented in Figure 2. The findings of the study left few pre-service teachers who had low SRL in the indicators of self-motivation belief (0.94%), task analysis (4.67%), self-control (4.67%), self-observation (3.74%), self-judgment (8.41%), and self-reaction (0.94%). The self-control indicator indicates that the majority of prospective chemistry teachers had moderate performance.

Figure 2

Profile of Self-Regulated Learning in Solution Chemistry



	Self-Motivation Belief	Task Analysis	Self-Control	Self-Observation	Self-Judgment	Self-Reaction
Very High	8,41	9,35	13,08	9,35	4,67	11,21
High	61,68	47,66	40,19	55,14	48,60	47,66
Medium	28,97	38,32	41,12	31,78	38,32	40,19
Low	0,94	4,67	4,67	3,74	8,41	0,94
Very Low	0,00	0,00	0,94	0,00	0,00	0,00

The achievement of indicators from SRL as shown by the research findings (Figure 2) exhibited that the majority of prospective chemistry teachers had "high" and "very high" SRL, although there were a number of prospective chemistry teachers who had "low" SRL in all indicators and "very low" on the self-control indicator.

The research hypotheses were tested through the Pearson Product Moment correlation analysis. Before being analyzed through Pearson Product Moment correlation, the data were analyzed using the normality test. The results of the normality test can be seen in Table 2.

Table 2

Test of Normality

	Kolmogorov-Smirnov[a]		
	Statistic	df	Sig.
Metacognitive Skills	.086	73	.200*
Self-Regulated Learning	.098	73	.079
a. Lilliefors Significance Correction			
*. This is a lower bound of the true significance.			
N		73	

Based on the findings of the analysis in Table 2, it can be seen that the metacognitive skills data was normally distributed with a significance value of 0.200 > 0.05, and the self-regulated learning data was also normally distributed with a significance value of 0.079 > 0.05. Because the normal assumptions have been fulfilled, it is followed by hypothesis testing using the Pearson Product Moment correlation analysis. The findings of the Pearson Product Moment correlation analysis can be seen in Table 3.

Table 3

Correlations

		Metacognitive Skills	Self-Regulated Learning
Metacognitive Skills	Pearson Correlation	1	.232
	Sig. (2-tailed)		.039
	N	73	73
Self-Regulated Learning	Pearson Correlation	.232	1
	Sig. (2-tailed)	.039	
	N	73	73

Based on the findings of hypothesis testing, it can be seen that there was a significant relationship between metacognitive and self-regulated learning with a significance value of 0.039 < 0.05. This means that H0 is rejected and the research hypothesis "there is a relationship between metacognitive skills and self-regulated learning of prospective chemistry teachers on the use of Metacognitive Skill-Based Teaching Materials in solution chemistry" is accepted. The result of Pearson Correlation calculation shows that the correlation coefficient is 0.232. This means that there is a relationship between metacognitive skills and self-regulated learning was positive and significant but weak.

The results of the regression analysis related to the correlation between prospective chemistry teachers' metacognitive skills and self-regulated learning at the implementation of metacognitive skill-based teaching materials can be seen in Table 4 and Table 5.

Table 4

Regression Coefficients of Correlation between Metacognitive Skills and Self-Regulated Learning on the Use of Metacognitive-Based Teaching Materials

Model		Unstandardized Coefficient		Standardized Coefficient	t	Sig
		B	Std. Error	Beta		
1	(Constant)	30.078	8.218		3.146	.202
	Metacognitive skills	.340	.075	.401	4.560	.000

Table 5

Regression Related to the Correlation between Metacognitive Skills and Self-Regulated Learning Results on the Use of Metacognitive-Based Teaching Materials

Model	R	R Square	Adjusted R Square	Std Error of the Estimate
1	.443[a]	.196	.181	4.19364

Note. a. Predictors: (Constant), metacognitive skills

Table 4 shows that the regression equation is Y = 0.340X + 30.078. The regression coefficient of 0.340 shows that each metacognitive skill increases by 1 point, so self-regulated learning will increase by 0.340 points. Other than that, t = 4.560 with a significance level of 0.000 <0.05, thus Ho is rejected, or in other words, the variable metacognitive skills have a significant effect on self-regulated learning. Table 5 shows that the reliability value is 0.196. Thus, it can be concluded that metacognitive skills have a contribution as much as 19.6% toward the increase of prospective chemistry teachers' self-regulated learning, and the remaining 80.4% is probably the contribution of the other factors, other than metacognitive skills.

Discussion

The result of this study reveals some important point, first, implementation metacognitive skill-based teaching materials could improve metacognitive skills. This finding suggests that practicing metacognitive skills could make prospective chemistry teachers to be aware of learning, plan their learning, control the learning process, and evaluate the extent of their own abilities and reflect on their learning, including assessing their weaknesses and strengths. Secondly, the implementation of metacognitive skill-based teaching materials could build self-regulated learning. It means knowledge of cognition and regulation of cognition have worked together to shape prospective chemistry teachers into self-regulated learners. Thirdly, there was a positive and significant relationship between metacognitive skills and self-regulated learning. It means that the higher the prospective chemistry teachers' metacognitive skills, the higher the level of self-regulated learning and vice versa.

Metacognitive skills refer to higher-order thinking which involves active control in the cognitive process of learning to solve a problem. In the context of learning, activities such as planning how to approach a given learning task, monitoring comprehension, and evaluating progress at completing a task are natural metacognitive. Metacognitive skills can be empowered through training using metacognitive skill-based teaching materials in learning like the findings in this study which are described as follows. By using Metacognitive Skill-Based Teaching Materials at Solution Chemistry, prospective chemistry teachers: 1) were able to manage their learning by applying indicators of metacognitive skills through student worksheets. In working on student worksheets, each prospective chemistry teacher should take several steps to reach a conclusion. These stages are: (a) first, prospective chemistry teachers were given a problem/phenomenon that is often encountered in everyday life which is presented at the beginning of the student worksheet. Prospective chemistry teachers solved problems by identifying problems in phenomena by using known knowledge (P2), then goal-setting (P1) and determined the learning strategies (P3) to solve problems; (b) second, prospective chemistry teachers solved problems using learning strategies and known knowledge through practice activities or using other learning resources for finding the truth of a concept according to the problem/task given. At this stage, prospective chemistry teachers monitored the relevance of existing knowledge to the used learning strategies (M1), monitored the achievement of objectives in making conclusions (M2); and (c) third, prospective chemistry teachers evaluated their thinking processes and outcomes (E); (2) By applying indicators of metacognitive skills, prospective chemistry teachers could improve understanding of each solution chemistry concept which was characterized by an increase in the mean post-test scores and most of the indicators of metacognitive skills had high N-Gain, which means that prospective chemistry teachers have been able to improve metacognitive skills.

This result is in line with previous research that reveals that giving exercise with effective metacognitive skills developed metacognitive control so that it could improve student understanding (Zhao et al., 2014). Metacognitive skills are important in learning and constitute a strong predictor of academic success (Dunning et al., 2003). This finding is also reinforced constructivist theory which lecturers encouraged reflective and autonomous thinking of students (Slavin, 2009). According to Anderson and Nashon (2006), metacognitive skills can influence the construction of a student's mastery of concepts.

The results of this study also found that there were still several prospective chemistry teachers who had low ability in indicators of monitoring the relevance of the known knowledge to the learning strategies used and also evaluating thought processes and outcomes. Those difficulties could not be avoided because the prospective chemistry teachers were still in the training stage in empowering metacognitive skills through various representations of chemical phenomena that were being studied, as stated by Rivers (2001). Nevertheless, most of them already had high abilities and got very high on all indicators of metacognitive skills. This finding was following Costa and Kallick (2001) who stated that metacognitive skills are the ability to know what is known and unknown; the ability to determine plans and strategies to achieve the information needed; the ability to have awareness in taking steps and problem-solving strategies; and the ability to reflect and evaluate the productivity of thought processes.

The study also found that there was a drastic increase in the self-regulated learning of prospective chemistry teachers because they managed to build their own knowledge independently, which means that learning activities were able to shape learning independence so that they could master the concepts as well. These results are in line with Slavin's (2009) idea that independent prospective chemistry teachers are the people who have knowledge of effective learning strategies and when to use them. As performed by the prospective chemistry teachers in this study, namely determined the learning strategies (P3) to solve problems according to the results of problem identification from phenomena in the worksheet.

These results also strengthen that self-regulated learning of prospective chemistry teachers is a form of individual learning that depends on intrinsic learning motivation and self-motivation beliefs, autonomously develops measurements (cognition, metacognition, and behavior), and monitors learning progress (Baumert, 2002; Pintrich, 2000). Likewise, student self-regulated learning showed individuals who often get high achievements were students who had self-regulated learning (Boekarts et al., 2000).

Metacognitive skills correlate with self-regulated learning by positive correlation. Metacognitive skills as the personal factor for a person to control and manage their learning is correlated for a person's self-regulated learning. The variable metacognitive skills have a significant effect on self-regulated learning and have a contribution as much as 19.6% toward the increase of a person's self-regulated learning. This result is in line with previous research that reveals that both metacognitive skills and self-regulated learning include measuring the degrees to which individuals are metacognitively, motivationally, and behaviourally active participants in their own learning processes (Zimmerman, 2002). Previous studies have also shown that general academic averages could predict levels of self-regulated learning (Rajabi, 2012) and the use of metacognitive skills was positively correlated to academic achievement in various disciplines (Hakan, 2016) and metacognitive has an impact on self-regulated learning (Sharaff et al., 2020).

Most prospective chemistry teachers already have self-motivation belief in completing their assignments. This indicated by the courage of prospective chemistry teachers in setting goals and determining learning strategies in solving problems/tasks was one of the findings in this study. These results are in accordance with the results of Marcou and George (2005) in their study, stating that learning independence is closely related to self-motivation belief. This condition was not much different from the high ability of student task analysis. Moreover, the results of this study are in accordance with the opinion of Soylu et al. (2008), in which the characteristics of being independent learners had the habit of making plans and goals. Goal setting and strategic planning were the embodiments of task analysis (Boekarts et al., 2000).

The same thing also happened to the ability of self-control in making and implementing plans that have been made. In addition, the ability of self-observation of prospective chemistry teachers in learning was shown by recording information independently in the portfolio, checking each step in completing assignments, and using pictures, diagrams, and graphs in learning, understanding, and monitoring work results. For example, "When a lecturer gives a problem in the form of a phenomenon related to daily life related to solution chemistry, namely about making ice cream and floating ponds, the ability of self-observation of prospective chemistry teachers in learning was indicated by recording information what they know about the given phenomenon. The prospective chemistry teachers immediately gathered facts related to these problems, including identifying the principle of depression of freezing point in the process of making ice cream and the principle of decrease in solution vapor pressure." In this case, each prospective chemistry teacher was immediately enthusiastic about collecting the known facts. So they were able to identify problems according to what they knew. This is in accordance with the view of Boekarts et al. (2000) that in monitoring, students must have self-control and self-observation to form a more personal self-awareness in increasing self-effectiveness. The results of this study are in accordance with research results which stated that diaries or portfolios can be used to measure the self-regulated learning of prospective chemistry teachers who monitor the development of processes (Schmitz & Wiese, 2006).

The ability of self-judgment and self-reaction was demonstrated by prospective chemistry teachers in evaluation of themselves against the performance used in completing assignments, by examining the overall understanding of the problem, calculations, units, and so on, and in assessing the suitability of learning outcomes with learning objectives. In addition, prospective chemistry teachers had been able to explain the cause-and-effect attribution of the results achieved, which showed confidence that the used learning strategy has helped in understanding the task completion and self-confidence with answers that complete its mission. The results of this study are in line with the view of Arends and Kilcher (2010) that in decision-making, where students read or review, correct errors or misunderstandings, and choose more appropriate learning strategies. This opinion strengthens the understanding that a concept can occur based on the results of self-evaluation and self-reflection (Wenning, 2006) and learning based on self-assessment will correctly produce meaningful knowledge (Kuiper, 2002).

Limitations of The Research

This study had a limitation, namely, the research only discusses the relationship between metacognitive skills and self-regulated learning. Though metacognitive skills are very important to be empowered in the education system because it can strengthen individuals' ability to think at a high level and increase academic success (Flavell, 2004). In addition, metacognitive skills are a dimension of knowledge that refers to increase awareness about thinking or cognitive and learning processes. Thinking is a process that produces a new mental representation through the transformation of information involving complex interactions between various mental processes, such as judgment, abstraction, reasoning, imagination, and problem-solving. Therefore, further researches are expected to be able to discuss the relationship between metacognitive skills and problem-solving or reasoning processes to improve academic success.

Conclusion and Implications

The implementation of metacognitive skill-based teaching materials can improve the metacognitive skills, build self-regulated learning of prospective chemistry teachers, and metacognitive skills have a significant correlation on self-regulated learning with positive correlation. The majority of prospective chemistry teachers had metacognitive skills and self-regulated learning with high and very high criteria in learning chemistry on each indicator, including self-motivation beliefs, task analysis, self-control, self-observation, self-judgment, and self- reaction. The effectiveness of metacognitive skill-based teaching materials in developing metacognitive skills and building self-regulated learning of prospective chemistry teachers majoring in chemistry had an impact on the problem-solving process when students have metacognitive skills, enabling them to conduct investigations and recognize process in the application of scientific knowledge.

Therefore, for further analysis and study regarding the formation of prospective chemistry teachers' SRL must initiate activities that can motivate and give them the opportunity to learn, understand, and recognize information received in the classroom and in their daily lives. This will make prospective chemistry teachers more independent in facing new situations. Lecturers must also function as facilitators by providing opportunities for prospective chemistry teachers in trying to understand by exploring and investigating themselves.

Acknowledgments

The research reported in this article was supported by the Indonesian Ministry of Research and Technology of Higher Education through applied product research. The author would like to thank the students of the Chemistry Education program in the first year of 2017 at the Mathematic and Natural Science Faculty in Surabaya State University who are directly involved in the development of metacognitive skills and learning independence.

References

Adebayo, F. A. (2015). Time management and students academic performance in higher institutions - A case study of Ekiti state. *International Research in Education*, *3*(2), 1–12. https://doi.org/10.5296/ire.v3i2.7126

Anderson, D., & Nashon, M. (2006). Predators of knowledge construction: Interpreting students' metacognition in an amusement park physics program. *Science Education*, *91*, 298–320. https://doi.org/10.1002/sce.20176

Arends, R. I.,& Kilcher, A. (2010). *Teaching for student learning: Becoming an accomplished teacher*. Routledge Taylor & Francis Group. https://doi.org/10.4324/9780203866771

Arikunto, S. (2006). *Prosedur penelitian: Suatu pendekatan praktik* [Research procedure: A practical approach]. PT Rineka Cipta.

Asyari, M. (2016). Improving critical thinking skills through the integration of problem based learning and group investigation. *International Journal for Lesson and Learning Studies*, *5*(1), 36–44. https://doi.org/10.1108/IJLLS-10-2014-0042

Azizah, U., & Nasrudin, H. (2016). Empowerment of student's thinking skills through development instructional materials basic chemistry based metacognitive. *Prosiding Seminar Nasional Kimia dan Pembelajarannya*, *2016*, 176–181. https://doi.org/10.1088/1742-6596/1108/1/012122

Azizah, U. & Nasrudin, H. (2018). Development of chemistry instructional materials based on Cooperative Group Investigation (CGI) to empower thinking skills. *IOP Conf. Series: Journal of Physics: Conf. Series (JPCS)*, *1108*(2018), 012122.

Azizah, U., Suyono, & Suyatno (2014). Pengembangan instrumen untuk mengukur kemandirian belajar mahasiswa [Development of instruments to measure student learning independence]. *Prosiding Seminar Nasional Kimia*, *2014*, 155–159.

Bakırcı, H., & Çepni, S. (2016). The ınfluence of the common knowledge construction model on middle school sixth grade students' critical thinking skills: a case of light and sound unit. *İnönü University Journal of the Faculty of Education*, *17*(3), 185–202.

Baumert. (2002). Self-regulated learning as cross-cultural concept. http://www.mpib-berlin.mpg.de/pisa/pdfs/ccengl.pdf

Bawaneh, A. K. (2019). Science teachers' practice level of active teaching in classroom. *International Journal of Recent Technology and Engineering (IJRTE)*, *8*, 1041–1048. https://doi.org/10.35940/ijrte.B1124.0982S919

Boekaerts, M., Pintrich, P., & Zeidner, M. (2000). *Handbook of self-regulation*. Academic Press. https://doi.org/10.1016/B978-012109890-2/50030-5

Boekaerts, M., & Cascallar, E. (2006). How far have we moved toward the integration of theory and practice in self-regulation?. *Educational Psychology Review*, *18*, 199–210. https://doi.org/10.1007/s10648-006-9013-4

Chaiyapha, P., Chayajarus, K., & Chairam, S. (2011). Investigation of high school students' understanding of acid-base chemistry based on jigsaw method. *Pure and Applied Chemistry International Conference*, 139–142.

Cooper, M. M., & Sandi-Urena, S. (2009). Design and validation of an instrument to assess metacognitive skillfulness in chemistry problem solving. *Journal of Chemical Education*, *86*(2), 240. https://doi.org/10.1021/ed086p240

Costa, A. L., & Kallick, B. (2001). Describing 16 habits of mind. http://www.habits-of-mind.net

Cohors-Fresenborg, E. & Kaune, C. (2007). Modelling classroom discussions and categorising discursive and metacognitive activities (pp. 1180-1189) [Paper presentation]. Proceedings of CERME 5, Lacarna, University of Cyprus. http://ermeweb.free.fr/CERME5b

Demirel, M., Aşkın, İ., & Yağcı, E. (2015). An investigation of teacher candidates' metacognitive skills. *Procedia – Social and Behavioral Sciences*, *174*, 1521–1528. https://doi.org/10.1016/j.sbspro.2015.01.783

Dunning, D., Johnson, K., Ehrlinger, J., & Kruger, J. (2003). Why people fail to recognize their own incompetence?. *Current Directions in Psychological Science, 12*(3), 83–87. https://doi.org/10.1111/1467-8721.01235

Effendy. (2006). *A-level chemistry for senior high students volume 2A*. Bayumedia Publishing.

Flavell, J. H. (2004). Metacognition and cognitive monitoring: A new area of cognitive developmental inquiry. *American Psychology*, *34*(10), 906–911. https://doi.org/10.1037/0003-066X.34.10.906

Fraenkel, J. R., & Wallen, N. E. (2009). *How to design and evaluate research in education*. Mc Graw Hill.

Funke, J. (2010). Complex problem solving: a case for complex cognition?. *Cognitive Processing*, *11*, 133–142. https://doi.org/10.1007/s10339-009-0345-0

Garrett, J., Alman, M., Gardner, S., & Born, C. (2007). Assessing students' metacognitive skill. *American Journal of Pharmaceutical Education*, *71*(1), 14–16. https://doi.org/10.5688/aj710114

Hacker, D. J., Dunlosky, J., & Graesser, A. C. (2009). *Handbook of metacognition*. Routledge Taylor and Francis.

Hakan, O. (2016). Evaluation of metacognitive competence of pre-service music teachers in terms of some variables. *Educational Research and Reviews*, *11*(8), 713–720. https://doi.org/10.4324/9780203876428

Hake, R. (2002). Relationship of individual student normalized learning gains in mechanics with gender, high school physics, and pretest scores on mathematics and spatial visualization. http://www.physics.indiana.edu/

Hargis, J. (2000). The self-regulated learner advantage: Learning science on the internet. *The Electronic Journal for Research in Science & Mathematic Education, 4*(4).

Hassel, S., & Ridout, N. (2018). An investigation of first-year students' and lecturers' expectations of University Education. *Frontiers in Psychology*, *8*(1), 1–13. https://doi.org/10.3389/fpsyg.2017.02218

Jaleel, S., Premachandran, P. (2016). A study on the metacognitive awareness of secondary school students. *Universal Journal of Educational Research*, *4*(1), 165–172. https://doi.org/10.13189/ujer.2016.040121

Jiang, Y., Ma, L., & Gao, L. (2016). Assessing teachers' metacognition in teaching: the teacher metacognition inventory. *Teaching and Teacher Education*, *59*, 403–413. https://doi.org/10.1016/j.tate.2016.07.014

Kipnis, M., & Hofstein, A. (2007). The inquiry laboratory as a source for the development of metacognitive skills. *International Journal of Science and Mathematics Education*, *6*(3), 601–627. https://doi.org/10.1007/s10763-007-9066-y

Kuiper, R. (2002). Enhancing metacognition through reflective use of self-regulated learning strategies. *Journal of Continuing Education in Nursing*, *33*(2), 78–87. https://doi.org/10.3928/0022-0124-20020301-11

Marcou, A., & George, P. (2005). *Motivational belief, self-regulated learning, and mathematical problem-solving*. *Proceedings of the 29th Conference of the International Group for the Psychology of Mathematics Education*, 3, 297–304, Melbourne.

Metin, M. (2011). Effects of teaching material based on 5E model removed pre-service teachers' misconceptions about acids-bases. *Bulgarian Journal of Science and Education Policy (BJSEP)*, *5*(2), 274–302.

Ministry of Education and Culture. (2014). *Panduan penyusunan capaian pembelajaran lulusan program studi* [Guidelines for the preparation of learning outcomes of study program graduates]. General Directorate of Learning and Student Affairs.

Ministry of Research, Technology and Higher Education Regulation. (2015). Standar nasional pendidikan tinggi [National standards of higher education]. https://lldikti3.ristekdikti.go.id/v5/2016/01/15/permenristedikti-nomor-44-tahun-2015-tentang-standar-nasional-pendidikan-tinggi/

Moseki, M., & Schulze, S. (2010). Promoting self-regulated learning to improve achievement: A case study in higher education. *Africa Education Review*, *7*(2), 356–375. https://doi.org/10.1080/18146627.2010.515422

Nasrudin, H., & Azizah, U. (2010). Improvement thingking skills and scientific attitude using the implementation of "group-investigation cooperative learning" contextual oriented at acid, base and salt topic in junior high school [Paper presentation]. *Proceedings of the 4th International Conference on Teacher Education,* Join Conference UPI & UPSI Bandung, Indonesia.

Peng, C. (2012). Self-regulated learning behavior of college students of science and their academic achievement. *Physics Procedia*, *33*, 1446–1450. https://doi.org/10.1016/j.phpro.2012.05.236

Pinarbasi, T., Sozbilir, M., & Canpolat, N. (2009). Misconceptions about colligative properties: Boiling point elevation and freezing point depression. *Chemistry Education: Research and Practice*, *10*, 273–280. https://doi.org/10.1039/B920832C

Pintrich, P. R. (2000). The role of goal orientation in self-regulated learning. In M. Boekaerts, P. R. Pintrich & M. Zeidner (Eds.), *Handbook of self-regulation* (pp. 451–502). Academic Press. https://doi.org/10.1016/B978-012109890-2/50043-3

Presidential Regulation. (2017). Penguatan pendidikan karakter [Strengthening character education]. https://www.kemenkopmk.go.id/content/perpres-no-87-tahun-2017

Rajabi, S. (2012). Towards self-regulated learning in school curriculum. *Procedia Social and Behavioral Science*, *7*, 344–350. https://doi.org/10.1016/j.sbspro.2012.06.661

Rompayom, P., Tambunchong, C., Wongyounoi, S., & Dechsri, P. (2010). The development of metacognitive inventory to measure student' metacognitive knowledge related to chemical bonding conceptions [Paper presentation]. *International Association for Educational Assessment (IAEA)*.

Rickey, D., & Stacy, A. M. (2000). The role of metacognition in learning chemistry. *Journal of Chemical Education, 77*(7), 915–920. https://doi.org/10.1021/ed077p915

Rivers, W. (2001). Autonomy at all costs: An ethnography of metacognitive self-assessment and self-management among experienced language learners. *The Modern Language Journal*, *86*(2), 279–290. https://doi.org/10.1111/0026-7902.00109

Santrock, J.W. (2002). *Life span development*. Erlangga.

Santrock, J.W. (2007). *Educational psychology*. McGraw Hill Ryerson Limited.

Schraw, G. (2001). Metacognition in learning and instruction: Theory, research, and practice. In H. J. Hartman (Ed.), *Metacognition in learning and instruction* (pp. 3-16). Kluwer Academic Publishers.

Schmitz, B., & Wiese, B. (2006). New perspectives for the evaluation of training session in self-regulated learning: Time-series analyses of diary data. *Contemporary Educational Psychology*, *31*(1), 83–88. https://doi.org/10.1016/j.cedpsych.2005.02.002

Shannon, S. V. (2008). Using metacognitive strategies and learning styles to create self-directed learners. *Institute for Learning Styles Journal*, *1*, 14–28.

Sharaff, S., Rishipal, Tripathi, M., Biwal, R. K., & Saxena, A.S. (2020). Impact of metacognitive strategies on self-regulated learning and intrinsic motivation. *Journal of Psychosocial Research, 15*(1), 35–46. https://doi.org/10.32381/JPR.2020.15.01.3

Sirhan, G. (2007). Learning difficulties in chemistry: An overview. *Journal of Turkish Science Education*, *4*(2), 2–20.

Slavin, R. E. (2009). *Educational psychology: Theory and practice*. Prentice-Hall, Inc.

Soylu, M. Y., Akkoyunlu, B., & Azer, S. A. (2018). An investigation of self-directed learning skills of undergraduate students. *Frontiers in Psychology*, *9*, 1–14. https://doi.org/10.3389/fpsyg.2018.02324

Thomas, G. P. (2012). Metacognition in science education: Past, present and future considerations. In B. J. Fraser, K. Tobin, & C. J. McRobbie (Eds.), *Second international hand-book of science education* (pp. 131–144). Springer. https://doi.org/10.1007/978-1-4020-9041-7_11

Watters, D. J., & Watters, J. (2006). Student understanding of pH- i don't know what the log actually is, i only know where the button is on my calculator. *Biochemistry and Molecular Biology Education*, *34*(4), 278–284. https://doi.org/10.1002/bmb.2006.494034042628

Wenning, C. J. (2006). A framework for teaching the nature of science. *Journal of Physics Teacher Education Online*, *3*(3), 3–10.

Zhao, N., Wardeska, J. G., McGuire, S. Y., & Cook, E. (2014). Metacognition: An effective tool to promote success in college science learning. *Journal of College Science Teaching*, *43*(4), 48–54. https://doi.org/10.2505/4/jcst14_043_04_48

Zimmerman, B. J. (2008). Investigating self-regulation, and motivation: Historical background, methodological developments, and future prospects. *American Educational Research Journal*, *45*, 166–183. https://doi.org/10.3102/0002831207312909

Zimmerman, B.J., & Martinez-Pons, M. (2001). Students differences in self-regulated learning: Relating grade, sex, and giftedness to self-efficacy and strategy use. *Journal of Educational Psychology*, *82*(1), 51–59. https://doi.org/10.1037/0022-0663.82.1.51