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Investigating Relationships among Pre-Service Science Teachers' Conceptual Knowledge of Electric Current, Motivational Beliefs and Self-Regulation

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The purpose of this study is to examine relationships among pre-service science teachers' conceptual knowledge of electric current, motivational beliefs, and self-regulation. One hundred and twenty-seven students (female = 107, male = 20) enrolled in the science education program of a public university in Ankara participated the study. A concept map technique was used to determine students' conceptual knowledge level of electric current. To determine students' motivational beliefs and self-regulation, a scale developed by Velayutham, Aldridge, and Fraser (2011) was first translated into Turkish and adapted to Turkish culture and then used as a measurement tool. Results showed that students' motivational beliefs were positively associated with their self-regulation, and students' task value, self-efficacy, and self-regulation were positively related with students' conceptual knowledge of electric current. These results show that students' motivational beliefs and self-regulation have important roles in students' conceptual knowledge level when assessed using concept map technique.

Keywords: conceptual knowledge, motivational beliefs, scale adaptation, self-regulation

INTRODUCTION

In science education, students' motivation and self-regulation have been two of the most frequently studied topics in recent years (Fortus & Vedder-Weiss, 2014; Johnson & Sinatra, 2013). According to findings of these studies, students' motivational beliefs and self-regulation appeared to be among the most important factors that influence science learning. The science education community emphasizes the level of subject matter knowledge as a primary factor in successfully understanding science concepts. Prior knowledge is also regarded as a major factor in successful learning. This model of successful science learning seems to be limited,

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especially when considering the recent findings of students' motivation and self-regulation studies (Johnson & Sinatra, 2013). The importance of these constructs arises from the need for students to be not only active learners in the knowledge constructing process but also to have competence beliefs and to also be active learners in the intrinsic and extrinsic process. Students who have some goals, values, and competence beliefs may engage actively in the processes of monitoring, controlling, and regulating their own learning (Schunk & Zimmerman, 2008; Zimmerman, 2002). According to Sinatra and Pintrich (2002), students are also active learners in affective and behavior aspects. From this perspective, motivation and self-regulation thought as intentional conceptual change constructs provides a better model for the process of structuring knowledge in students' minds (Sinatra & Pintrich, 2002). Without taking into consideration the affective and behavior aspects of learners, learning and understanding of basic science concepts, which is one of the most important components in developing scientifically literate people, will be indispensable (Laugksch, 2000). For this reason, it is important to take into consideration students' characteristics related to cognitive and motivational features in the learning process of basic science concepts.

State of the literature

- It is well known that motivation and self-regulation have pivotal roles in students' conceptual change process and science achievement.
- Motivation and self-regulation provide a better framework to understand the process of structuring knowledge in students' minds.
- Some researchers argue that answering multiple choice questions or solving traditional end-of-unit questions may not be an indicator of students' conceptual knowledge.

Contribution of this paper to the literature

- This study is unique as it combines relatively less studied constructs such as task value, learning goal orientation, self-regulation, and conceptual knowledge.
- In this study, students' conceptual knowledge was measured using a network concept map technique instead of traditional achievement tests. For this reason, results of this study have unique contributions to the literature.
- Another important contribution of study to the literature is adaptation to Turkish culture of the students' adaptive learning engagement in science questionnaire.

The science education literature has many studies which reveal the relationship between students' motivational beliefs and self-regulatory processes in science achievement (Bathgate, Schunn & Correnti, 2014; Demirel & Turan, 2010; DiBenedetto & Bembenutty, 2013; Ergene, 2011; Eymur & Geban, 2011; Hacıeminoğlu, Yılmaz-Tüzün & Ertepınar, 2009; Güvercin, Tekkaya & Sungur, 2010; Işık & Gücüm, 2013; Lee, Lee & Bong, 2014; Pajares, Britner & Valiante, 2000; Schraw, Crippen & Hartley, 2006; Şen, 2011; Şenal, 2010; Yumuşak, 2006). The findings of these studies indicate that students' motivational beliefs and self-regulation are related to achievement. However the findings reported in the literature regarding these relationships are inconsistent. For example, Şenal (2010) investigated the relationship between high school students' science achievement and motivational beliefs. The results of study showed that students' self-efficacy belief, learning goal orientation, and performance goal orientation are statistically significant and positive predictors of students' science achievement. Similarly, Pajares, Britner, and Valiante (2000) found a positive relationship between students' science achievement and self-efficacy in their study with seventh grade students. Finally, DiBenedetto and Bembenuty (2013) showed that there is a positive relationship between students' self-efficacy and science achievement in a similar study with college students. However, Hacıeminoğlu, Yılmaz-Tüzün, and Ertepınar (2009) could not find a significant relationship among primary students' science achievement in the subject of properties of matter, self-efficacy, and learning goal orientation. Furthermore, Ergene (2011) could not find a significant relationship between students' science achievement and achievement motivation in his study with high school students. In a similar way, the findings of studies which investigate the relationship between self-regulation and science achievement are inconsistent. For instance, Velayutham et al. (2011) showed that there is a positive relationship between students' science achievement and self-regulation. However, Pajares et al. (2000) could not find any statistically positive relationship between science achievement and self-regulation in their study.

Reasons for this particular inconsistence seem to stem from two possible sources. One branch is requisitioning the structure and function of current motivation theories. The second one is requisitioning assessment methods of students' conceptual understanding. Pintrich (2003) and Maehr and Zusho (2009) point out that the motivational construct has been mainly regarded as a whole construct, which leads to a limited understanding of the effects on teaching and learning when dealing with this construct. They argue that the motivational construct is indeed a complex phenomenon and has several components to it. Pintrich (2003) suggests that competence and value beliefs should be considered as vital components of this construct because these components have an important effect on learning and achievement as a whole and/or single component. Furthermore, studies dealing with students' self-regulation focus mainly on the cognitive and meta-cognitive strategy aspects of this construct. Less work is conducted on the effort phases of self-regulation, which, according to Pintrich (2003), need closer attention in future research (Pintrich, 2003; Boekaets & Cascallar, 2006; Velayutham & Aldridge, 2013). Therefore, research needs to redefine the motivational construct by utilizing new studies focusing on the limitations mentioned above.

The source of the second problem is the assessment methods and interpretation of students' conceptual understanding. Usually students' conceptual understanding is assessed through the combination of end-of-unit, multiple choice, and/or open-ended tests. However, recent studies indicated (Ateş, 2008; Ateş & Çataloğlu, 2007; Sarı, Altıparmak & Ateş, 2013) that test format, structure, and operational definition of student's achievement affect the interpretation of conceptual understanding and students' achievement. These studies have clearly shown that a successful score might not be a good indicator of a student's real level of conceptual understanding. Ates and Cataloglu (2007) emphasize that there is a need to repeat the studies which investigate factors affecting students' level of conceptual knowledge using appropriate measurement tools. It is evident from the literature that further studies conducted on students' redefined motivational beliefs, self-regulation, and conceptual knowledge may make a significant contribution to the literature. Towards this end we have adopted the "The Students' Adaptive Learning Engagement in Science" developed by Velayutham, Aldridge, and Fraser (2011) into Turkish and implemented it in order to find answers for the following research questions:

1. Is the motivation and self-regulation scale developed by Velayutham et al. (2011) a convenient measurement tool to use in Turkish for students who are majoring in science education?
2. What is the level of pre-service science teachers' conceptual knowledge of electric current measured using a concept map technique, motivational beliefs, and self-regulation?
3. What is the relationship among pre-service science teachers' conceptual knowledge of electric current, motivational beliefs, and self-regulation?

THEORETICAL FRAMEWORK

This section includes operational definitions of basic concepts used in the study and the reported relationships among these concepts.

Motivational beliefs and self-regulation

Motivation is defined as "a process whereby goal-directed activity is instigated and sustained" (Pintrich & Schunk, 1996, p. 5). The definition of motivation shows that motivation is closely related to students' physical activities such as effort and persistence and mental activities such as planning and organizing. Therefore, motivated students are keener to make an effort, persist longer, and organize subjects to be learned. Consequently, these activities may lead to a better understanding. There are a lot of theories about motivational beliefs of students. One of these theories is expectancy-value theory, which presents a more promising structure to explain students' motivational beliefs. Expectancy-value theory presents a model that involves students' reasoning that engages classroom activities and beliefs about their competence. Moreover, Pintrich (2003) claimed that expectancy-value theory provides a useful framework to analyze motivational beliefs such as self-efficacy, goal orientation, and task value.

Self-efficacy is defined as students' beliefs about their capability to learn or perform (Bandura, 1997). According to Schunk (1995), low self-efficacious students usually give up easily when they face a difficulty and are less likely to engage in challenging tasks, whereas self-efficacious students persist longer and show more effort when they face a difficulty and set challenging goals. As a result, self-efficacious students are more successful than their peers. Goal orientation, another component of motivational belief, is interested in the reasons students try to achieve specific goals. According to the expectancy-value theory, there are two types of goal orientation on a basic level, learning goal orientation and performance goal orientation. The reason students who have adopted learning goal orientation participate in lessons is to understand them accurately (Ames, 1992). These students find it important to improve their knowledge and skills about a subject as much as possible. Moreover, these students evaluate their success or failure in terms of their own standards and believe that effort is the main cause of their success or failure. The last component of motivational belief is task value, which explains different tasks' qualifications and how these qualifications affect the desire to accomplish a task (Wigfield & Eccles, 2000). Students' different task value beliefs toward science lessons affect their choices, efforts, persistence, and achievements through learning process in different ways. According to Eccles and Wigfield (1995), the most widely studied components of task value are importance, interest, and utility. Importance value indicates students' beliefs about how an activity enables them to realize their self-identity. Interest value, another task value component, is how much a student enjoys or hates an activity. The last task value component, utility value, indicates students' beliefs about how an activity is suitable for their future plans. It is necessary to evaluate all three task value beliefs in an integrated manner to comment about students' learning and achievements (Pintrich & Schunk, 1996).

A great majority of previous studies about motivational beliefs showed that each motivational belief is positively associated with science achievement (Barron & Harackiewicz, 2001; Kızılgüneş, Tekkaya, & Sungur, 2010; Pajares, 1996; Schunk & Pajares, 2002; Simpkins, Davis-Kean, & Eccles, 2006; Wigfield, 1994) and self-regulation (Pintrich, 1999; Pintrich, 2003; Pintrich & De Groot, 1990; Pintrich, Smith, Garcia, & McKeachie, 1993; Schunk & Pajares, 2002; Sungur, 2007b). However, the results of some studies showed that there was not a statistically significant relationship between motivational beliefs and science achievement (Ergene, 2011; Hacıeminoğlu, Yılmaz-Tüzün, and Ertepınar, 2009; Şenal, 2010).

Self-regulation is another important component of social cognitive theory (Bandura, 1991). Zimmerman (2002) defined self-regulation as self-generated thoughts, feelings, and actions that are planned and cyclically adapted to the attainment of personal goals. It usually occurs by the interaction of three cyclic stages. These stages may occur in random order but usually the forethought stage occurs before the stages of control-monitoring and reaction-reflection. Although there are several self-regulated learning models in the literature, these models share some basic assumptions. According to these assumptions, students are active learners throughout the process, have control over their learning, and have some goals. Students who are active throughout the process construct knowledge and are not knowledge receivers. Students who have control over their learning can plan, monitor, and regulate their learning, and students who have goals can regulate their learning by comparing their current achievements against their goal. When these assumptions are taken into account, Pintrich (2000) defined self-regulated learning as "an active, constructive process whereby learners set goals for their learning and then attempt to monitor, regulate, and control their cognition, motivation, and behavior, guided and constrained by their goals and the contextual features in the environment" (p. 453). As the definition of self-regulated learning shows, the cyclic nature of self-regulation occurs in three phases, namely, cognition, motivation, and behavior (Pintrich, 2000). Effort regulation is one of the important components of behavior regulation and has been a relatively less studied aspect of self-regulation. Corno (1994) defined effort regulation as "maintaining attention and effort although [there are] distractive factors of environment" (p. 229). The triadic nature of self-regulation starts with forethought stage in the effort regulation phase. In this stage, students specify their time and efforts and the people who help them. In monitoring and controlling stage, which is the second stage of self-regulation, students make observations against the criteria which is specified in first stage and make some regulations by showing more effort or allocating more time if it is necessary. In the last stage, reflection, students consider experiences that they gained through the process for another forethought stage.

In this study, the term "self-regulation" has been consistently used to describe effort regulation. Studies that investigate the relationship between students' achievement and self-regulation show that more self-regulated students are more successful (Dignath, Buettner & Langfeldt, 2008; Velayutham et al., 2011).

Conceptual knowledge

One of the desired goals of science education is to raise the science literacy of students. To reach this goal, students need to have an advanced conceptual understanding of science topics. There are many studies that investigate factors influencing students' conceptual understanding levels. In these studies, students' conceptual understanding level is usually assessed and evaluated by their performance on end-of-unit problems or achievement tests. Results of previous studies showed that students' high performance on achievement tests or in problem solving does not indicate a high level of conceptual knowledge (Ateş, 2008; Ateş & Çataloğlu, 2007; McDermott, 2001; Sarı, Altıparmak, & Ateş, 2013). Indeed, conceptual understanding is a different kind of knowledge type that depicts how the ideas associate with each other in a particular domain (Jonassen & Wang, 1993). Ausubel, Novak, and Hanesian (1978) emphasized the importance of conceptual knowledge by saying that learning is not only gaining concept knowledge in an isolated way but also requires making significant relationships among concepts.

Conceptual knowledge involves an understanding of a concept's own structure and its operational structure with other concepts rather than the storing of declarative knowledge in the mind. This means that concepts are not stored in an isolated way in individuals' minds; instead, each concept is stored with other concepts that are associated with it. Moreover, each concept gains meaning according to its relationship with other concepts. Also, the number of concepts and the intensity of links among concepts indicate the developmental level of conceptual knowledge. Accordingly, domain experts represent more elaborate structures while novices represent weak and inconsistent structures. Individuals who are relatively new in a domain have more irregular and limited conceptual knowledge while domain experts' conceptual knowledge is more regular and has advanced conceptual structures (Baxter, Elder, & Glaser, 1996).

METHOD

Design

In this study, a correlational research design, a quantitative research method, was used to investigate the relationship among pre-service science teachers' conceptual knowledge of electric current, motivational beliefs, and self-regulations toward science learning.

Population and sample

The research sample consisted of 127 students (female = 107, male = 20) who were enrolled in the General Physics Laboratory II class in the spring semesters of 2013 and 2014 in the science education program of a public university in Ankara. The sample of this study was determined by convenient sampling. Research has shown that students from all grades and even science teachers have struggled to understand topic of electric current. (Çıldır, 2005; Sencer & Eryılmaz, 2002). Teachers' insufficient and erroneous knowledge may lead students to learn the same misconceptions (Lederman, 1999; Magnusson, Borko, Krajcik & Layman, 1992). For this reason, it is important to reveal possible relationships between affective characteristics and teachers' well developed conceptual knowledge.

Instruments

Motivation and self-regulation toward science learning questionnaire

The Students' Adaptive Learning Engagement in Science (SALES) Questionnaire developed by Velayutham et al. (2011) was used to determine students' motivational beliefs and self-regulation toward science learning. This questionnaire has been used recently in various international studies and its validity and reliability has been proven in these studies (Velayutham, Aldridge, & Fraser, 2012; Velayutham & Aldridge, 2013). As mentioned in the research questions section of the paper, one of the purposes of this study was to adapt the SALES questionnaire to the Turkish language. The questionnaire has four sub-dimensions: learning goal orientation, task value, self-efficacy, and self-regulation. Each sub-dimension of the SALES has eight items in a five-point Likert scale.

Network concept map

Student's conceptual understanding of electric current was assessed through network concept maps. In this study, students were asked to construct network concept maps of electric current. Towards this end, students were provided with the 12 most frequently used core concepts of electric current previously determined by İnaltun (2013) and Çildir (2005). These 12 core concepts were electric current, electric charge, potential difference, electric field, electric force, electric energy, power supply, electric circuit, conductor, insulator, electrical resistance, and magnetic field. After being provided with the 12 core electric current concepts, students were expected to construct network concept maps. The evaluation (scoring) process was done utilizing McClure, Sonak, and Suen's (1999) relational with master map scoring technique. This particular technique utilizes an expert network concept map as a scoring template. See Figure 1 for detailed scoring

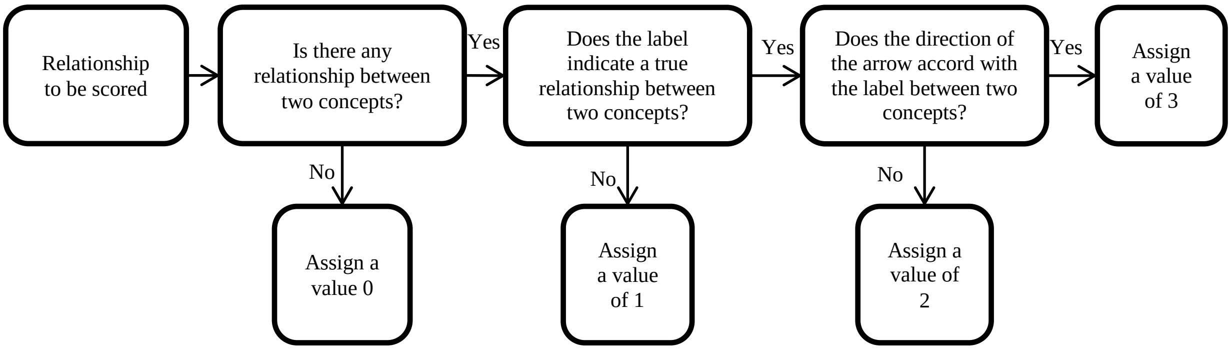

Figure 1. The rubric of McClure, Sonak, & Suen's master map scoring

procedure. Response scores of students for network concept maps in this study can range 0 to 36 based on the master map.

Measurement procedure

To begin, students were given training on how to construct a network concept map. While planning the lesson, the suggestions of Ruiz-Primo, Schultz, and Shavelson (2001) were taken into consideration. According to these suggestions, during a lesson researchers gave the students answers to questions such as: What are a concept and a concept map? Why are they used? What are the elements of a concept map? How many concept map types are there? How is a relationship between two concepts constructed? Finally, students were given some advice in coping with problems about constructing a concept map using Turkish grammar rules (Bağcı Kılıç, 2003). After instruction about how to construct a network concept map, students were given sample concepts from their daily lives and were asked to draw network concepts maps according to the rules. Moreover, researchers encouraged students to work with their friends. Students' concept maps were collected by the researcher and then analyzed according to concept mapping rules. In the next class researchers gave students' concept maps back and ensured that students noticed and refined their mistakes. Over the next two weeks, researchers continued to train students and give them corrected concept maps at the end of each week. In the implementation session, researchers gave students a concept map questionnaire which including concept map instructions and 12 core electric current concepts. Finally, students were asked to construct a network concept map using the 12 concepts given to them and were given 40 minutes to complete their concept maps. Students' concept maps were evaluated by the concept map scoring technique defined by McClure, Sonak, & Suen (1999) in Figure 1.

To determine students' motivational beliefs and self-regulation, the Turkish version of SALES, named the "Motivation and Self-Regulation toward Science Learning Questionnaire," was applied a week before the process of constructing concept maps. Students were asked to fill in the questionnaire and were informed superficially about the purpose and importance of the study. Before the questionnaire was distributed to the students, the researchers read the instructions of questionnaire in order to make sure that every student understood the instructions. Then students were given 15 minutes to complete the questionnaire.

Data analysis

Data collected for this study were analyzed for failure, missing, and extreme values before inferential statistical analysis. In this process, incorrect data entered into the computer were corrected and missing values were added using an EM algorithm. In analyzing the extreme values, data were transformed with z points and the data that were bigger than +3.32 critical value and lower than -3.32 critical value were excluded. At the end of these analyses, three observations were detected as extreme values and were removed. Finally, 124 data obtained from the sample were used for inferential analysis.

SPSS 20 was used to determine relationships among students' conceptual knowledge of electric current, learning goal orientation, task value, self-efficacy, and self-regulation toward science learning. Pearson correlation coefficients (r) were computed to examine the relationships among variables of the study.

FINDINGS

This section includes the findings for research questions of the study.

Findings for the first research question

The first research question of the study was whether the motivation and self-regulation toward learning science questionnaire developed by Velayutham et al. (2011) was usable when translated into Turkish and with Turkish pre-service science teachers. In the beginning of the process, researchers of this study communicated with the developers of the questionnaire via e-mail and obtained their opinion on adapting the scale to university students from a different culture. After getting the permission and opinions of the developers, adaptation studies were started. The process of adapting the questionnaire was carried out in two stages. In the first stage, to provide language equivalence, the questionnaire was translated from English to Turkish separately by both the two researchers and a specialist in science education. The three translated questionnaires were then pieced together and the translations were compared and contradictory items were discussed. Later, the questionnaire was translated back from Turkish to English by a researcher who was not involved in the first stage and was then compared with the original items. In the last stage, the scale was applied to 30 students and they were asked what they understood from each item and whether they had any problem understanding the statement in each item. After revising the questionnaire based on the students' feedback, the questionnaire was applied to 416 pre-service first, second, and fourth grade science teachers. In stage two, confirmatory factor analysis (CFA) was conducted on the Turkish version of the questionnaire. After the CFA, the following fit indexes were obtained: ($\chi 2/sd$) = 3.13, GFI = .82, AGFI = .79, RMSEA = .072, RMR = .038, CFI = .97, NFI = .95, NNFI = .96 and PGFI = .71. According to these findings, ($\chi 2/sd$) indicates a mediate fit; RMSEA indicates a good fit; RMR, CFI, NFI, and NNFI indicate a perfect fit; and, finally, GFI and AGFI indicate a weak fit. In the results of reliability analysis, Cronbach alpha was calculated as .90 for the dimension of learning goal orientation, .89 for the dimension of task value, .87 for the dimension of self-efficacy, and .86 for the dimension of self-regulation. Moreover, an item-total correlational analysis and an item distinctiveness test were conducted (Please see Appendix 2 for further information). Findings obtained from these analyses show that the SALES Questionnaire developed by Velayutham et al. (2011) was able to be adapted into Turkish and usable by Turkish students who study in science education departments. The adapted version of SALES can be seen in appendix A.

Findings for the second and third research question

The second research question of the study aimed to determine students' levels of conceptual knowledge of electric current, motivational beliefs, and self-regulation. The findings for the descriptive statistics of students' scores and the analyses of the relationships among variables of the study can be seen in Table 1.

Table 1. Descriptive statistics and correlation coefficients of the variables

Variables	$\bar{x}$	Min	Max	S	1	2	3	4	5
1. Learning goal orientation	33.7	29	39	2.11	1	.38**	.48**	.45**	.15
2. Task value	28.3	21	38	3.41		1	.44**	.44**	21*
3. Self-efficacy	29.3	19	38	3.69			1	.50**	.33**
4. Self-regulation	26.3	18	35	3.77				1	.31**
5. Conceptual knowledge	11.4	3	25	4.81					1

**p < .05, two tailed. **p < .01, two tailed*

The mean score of students' conceptual knowledge was very low (11.4/36.0). Results of the correlation analyses showed that students' conceptual knowledge scores were positively correlated with students' task value ($r = .21$, $p < .05$), self-efficacy ($r = .33$, $p < .01$), and self-regulation ($r = .31$, $p < .01$). On the other hand, there was no positive relationship between students' conceptual knowledge and learning goal orientation ($r = .15$, $p > .05$).

DISCUSSION AND RESULTS

In this study, the motivation and self-regulation questionnaire developed by Velayutham et al. (2011) was translated and adapted to Turkish language and culture and then relationships among pre-service science teachers' conceptual knowledge, motivational beliefs, and self-regulation were investigated.

In the scope of the adaptation of motivation and self-regulation toward science learning questionnaire, fit indexes were investigated and we concluded that the original structure of the Turkish version of questionnaire was verified. Additionally, Cronbach alpha coefficients obtained from reliability analysis showed that questionnaire was reliable. Another purpose of the study was to determine the level of students' conceptual knowledge of electric current, motivational beliefs and, self-regulation. Students' conceptual knowledge level of electric current was measured with using the concept map technique. According to this measurement, we saw that students' conceptual understanding levels were much lower than the maximum level that could be obtained from the concept map. This result indicates that students struggled to associate concepts correctly and in a sophisticated way and did not have the desired conceptual knowledge level about electric current. When students' motivational beliefs and self-regulation mean scores examined, we saw that the learning goal orientation mean had the highest score and the self-regulation mean had the lowest score. This research finding is compatible with findings of similar studies which were conducted with primary school, high school, and college students (Kızılgüneş, Tekkaya, Sungur, 2010; Sungur, 2007a, Sungur, 2007b).

The study findings show that there is no statistically significant relationship between students' adopted learning goal orientation and their conceptual knowledge of electric current. The results of the study do not match with the findings of the previous studies that investigated the relationship between students' science achievement and learning goal orientation (Barron & Harackiewicz, 2001; Velayutham et al., 2011). One of the possible reasons for this incompatible finding may be the various operational definitions of students' science achievement in different studies. In this research, the operational definition of students' science achievement was defined as students' conceptual knowledge of electric current measured by using concept maps. However, in other studies, science achievement is usually defined as students' GPA or scores obtained from achievement tests. Since these definitions are different cognitive outcomes, this may cause differences in the results of the studies. However, Hacıeminoğlu, Yılmaz-Tüzün, & Ertepınar (2009) similarly found that there is no significant relationship between students' learning goal orientation and science achievement.

The finding of a relationship between self-efficacy and conceptual knowledge is compatible with findings of the previous studies that investigated the relationship between self-efficacy and science achievement (Pajares, 1996; Schunk & Pajares, 2002, Velayutham et al., 2011; Wigfield, 1994). These findings show that students who have high level of self-efficacy show more effort in developing their conceptual knowledge and have more advanced relations between concepts. Pintrich and De Groot (1990) argued that one of the reasons for the relationship between self-efficacy and conceptual knowledge may be that self-efficacious students use deeper cognitive strategies. Students who use deep cognitive strategies prefer strategies such analyzing and paraphrasing relationships rather than memorizing and rehearsal. As a consequence, these deeper cognitive strategies may result in more advanced conceptual knowledge.

Task value is another motivational belief that had a statistically significant and positive relationship with students' conceptual knowledge of electric current. The significant relationship between students' conceptual knowledge and task value is compatible with the findings of previous studies (Battle & Wigfield, 2003; Velayutham et al., 2011). These studies show that students who find science learning more interesting, important, and useful have high conceptual knowledge. The reason for the lowest correlation coefficient between task value and conceptual knowledge may arise from the nature of task value beliefs because task value beliefs are a better predictor of students' behavioral choices than their achievements (Eccles, Wigfield & Schiefele, 1998). Studies have also shown that there was a significant relationship between the task value students gave to science learning and self-regulation. The relationship between the two variables is compatible with other findings in the literature (Pintrich, 2003; Sungur, 2007b). According to our findings, students who find science learning more important, interesting, and useful attempt to frequently plan, monitor, and regulate their time management and focus. Finally, we saw that there is a significant relationship between students' self-regulation and conceptual knowledge. Students who attempt to regulate their persistence, attention, and time frequently have more advanced conceptual knowledge. Velayutham et al. (2011) also reported similar results in their study.

In summary, we saw that students' conceptual knowledge measured by concept maps has a positive relationship with self-efficacy, task value, and self-regulation. Similarly, a great number of studies have found a positive relationship among these variables. However, the findings of this study are unique because of conceptual knowledge measuring technique and the operational definition of science achievement. Based on these findings, we conclude that motivation and self-regulation may lead pre-service science teachers to develope more coherent conceptual knowledge about electric current. However, experimental studies are needed to justify this claim.

For further studies, researchers may propose a model to investigate how motivational beliefs such as task value, learning goal orientation, and self-efficacy influence students' self-regulation and how the key facets of motivation and self-regulation both affect students' conceptual knowledge. Moreover, researchers may investigate relationships between different motivational constructs such as performance-avoidance goal orientation and performance-approach goal orientation with conceptual knowledge. These future studies may reveal more detailed information about relationships among motivation, self-regulation, and conceptual knowledge. On the other hand, in the literature there are different kinds of scoring methods for concept maps for evaluating students' conceptual knowledge. There are various opinions that argue that each scoring method evaluates students in different cognitive areas. For this reason, it may be helpful in future research to investigate how different scoring methods associate with students' motivational beliefs and self-regulation in order to see how different cognitive areas are associated with motivation and self-regulation.

According to findings of this study and other studies, motivation and self-regulation are critical roles for learning core science concepts. For this reason, it is important to determine and monitor students' levels of motivation and self-regulation toward science during instruction. Within that period, educators need a valid and reliable instrument to achieve this goal. The valid and reliable structure of the adapted version of SALES may make educators' work easier, enabling instructors to monitor their students' levels of motivation and self-regulation in an effective way during instruction and make some arrangements for enhancing students' motivation and self-regulation.

Finally, the study has some delimitations. First of all, the researchers focused only on students' conceptual knowledge of electric current and other science topics were excluded. Similarly, researchers studied only pre-service science teachers and other subjects were not included. In addition, the study has some limitations due to the nature of correlational research design. For this reason, it is important to conduct qualitative studies to get more detailed knowledge.

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Appendix A: FEN BİLİMLERİ ÖĞRENİMİ

MOTİVASYON VE ÖZ DÜZENLEME ÖLÇEĞİ

Anketi Tamamlayacak Öğrenciler için Yönergeler;

Aşağıda öğrencilerin fen derslerini öğrenme durumları ile ilgili bazı ifadeler yer almaktadır. Lütfen her bir ifadeyi özenli bir şekilde okuyunuz. Aşağıda belirtilen durumlardan sizin düşünce ve duygularınızı en iyi ifade ettiğini düşündüğünüz seçeneği işaretleyiniz.

Bu ankette doğru veya yanlış cevap yoktur. Önemli olan sizin fikrinizin ne olduğudur.

Ankette her bir maddeye verilebilecek cevaplar beş seçenekten oluşmaktadır. Bu seçenekler soldan sağa doğru; "*Kesinlikle katılmıyorum, Katılmıyorum, Biraz katılmıyorum biraz katılıyorum. Katılıyorum, Kesinlikle katılıyorum" ş*eklinde sıralanmışlardır. Her bir ifade için yukarıda belirtilen seçeneklerden size en uygun olan birini işaretleyiniz.

Anketi tamamladıktan sonra tüm seçeneklere cevap verdiğinizden emin olun. Ölçekte yer alan ifadelerden bazıları anlam olarak birbirlerine oldukça yakındır. Bu konuda endişelenmenize gerek yoktur. Sadece tüm ifadeler hakkındaki düşüncelerinizi işaretleyiniz.

FEN BİLİMLERİ ÖĞRENİMİ

MOTİVASYON VE ÖZ DÜZENLEME ÖLÇEĞİ

Öğrenme Hedef Yönelimi **Fen derslerinde…**	Kesinlikle Katılmıyorum	Katılmıyorum	Biraz Katılmıyorum Biraz Katılıyorum	Katılıyorum	Kesinlikle Katılıyorum
1. Hedeflerimden biri öğrenebildiğim kadar çok şey öğrenmektir.					
2. Hedeflerimden biri yeni fen konularını öğrenmektir.					
3. Hedeflerimden biri yeni bilimsel süreç/yöntem becerilerinde kendimi geliştirmektir.					
4.Üzerime düşen görevleri anlamak benim için önemlidir.					
5.Öğretilen yeni fen konularını öğrenmek benim için önemlidir.					
6. Bilimsel süreç/yöntem becerilerimi geliştirmek benim için önemlidir.					
7. Bana öğretilmek isteneni anlamak benim için önemlidir.					
8. Bilimsel fikirleri anlamak benim için önemlidir.					

Konu Değeri **Fen derslerinde…**	Kesinlikle Katılmıyorum	Katılmıyorum	Biraz Katılmıyorum Biraz Katılıyorum	Katılıyorum	Kesinlikle Katılıyorum
9. Öğrendiklerim günlük yaşamımda kullanılabilir.					
10. Öğrendiklerim ilgi çekicidir.					
11. Öğrendiğimi bilmek benim için yararlıdır.					
12. Öğrendiklerim bana yardımcı olur.					
13. Öğrendiklerim benimle ilgilidir.					
14. Öğrendiklerimin günlük yaşamda kullanma alanı vardır.					
15. Öğrendiklerim merakımı giderir.					
16. Öğrendiklerim beni düşünmeye teşvik eder.					
Öz yeterlik **Fen derslerinde…**	Kesinlikle Katılmıyorum	Katılmıyorum	Biraz Katılmıyorum Biraz Katılıyorum	Katılıyorum	Kesinlikle Katılıyorum
17. Öğretilen becerilerde kendimi geliştirebilirim.					
18. Zor işlerin nasıl yapıldığını anlayabilirim.					
19. Yapılacak işler zor olsa bile öğrenebilirim.					
20. Eğer çalışır çabalarsam zor işleri tamamlayabilirim.					
21. Sınavlarda iyi notlar alırım.					
22. Yaptığımız işleri öğrenebilirim.					
23. Öğretilen konuları anlayabilirim.					
24. Fen konularında iyiyimdir.					

Öz düzenleme **Fen derslerinde…**	Kesinlikle Katılmıyorum	Katılmıyorum	Biraz Katılmıyorum Biraz Katılıyorum	Katılıyorum
25. Yapmam gerekenler ilgi çekici olmasa da çalışmaya devam ederim.				
26. Yaptıklarım hoşuma gitmese de çok çalışırım.				
27. Ders dışında yapılacak daha önemli işlerim olsa da çalışmaya devam ederim.				
28. Derse konsantre olurum.				
29. İşlerimi ve ödevlerimi zamanında bitiririm.				
30. Yapılan iş zor olsa bile çalışmayı bırakmam.				
31. Konsantre olduğum için önemli noktaları kaçırmam.				
32. Yapmam gereken neyse bitirene kadar çalışmaya devam ederim.				

Appendix B

Results of Item Distinctiveness Test

Item No	Groups	$\bar{X}$	S	df	t
I1	Low Level	3.17	.80	222	23.863*
	High Level	5.00	.00		
I2	Low Level	2.96	.80	222	26.661*
	High Level	5.00	.00		
I3	Low Level	3.26	.77	222	23.779
	High Level	5.00	.00		
I4	Low Level	3.61	.72	222	20.176*
	High Level	5.00	.00		
I5	Low Level	3.25	.74	222	24.756*
	High Level	5.00	.00		
I6	Low Level	3.29	.80	222	22.522*
	High Level	5.00	.00		
I7	Low Level	3.58	.76	222	19.494*
	High Level	5.00	.00		
I8	Low Level	3.20	.71	222	26.537*
	High Level	5.00	.00		
I9	Low Level	2.73	.53	222	28.164*
	High Level	4.65	.47		
I10	Low Level	2.69	.59	222	28.451*
	High Level	4.71	.45		
I11	Low Level	3.34	.83	222	20.931*
	High Level	5.00	.00		
I12	Low Level	2.90	.64	222	34.249*
	High Level	5.00	.00		
I13	Low Level	2.18	.69	222	28.830*
	High Level	4.50	.50		
I14	Low Level	2.66	.60	222	26.923*
	High Level	4.64	.48		
I15	Low Level	2.53	.64	222	27.433*
	High Level	4.62	.48		
I16	Low Level	2.80	.69	222	33.315*
	High Level	5.00	.00		
I17	Low Level	3.10	.59	222	22.815*
	High Level	4.72	.44		
I18	Low Level	2.80	.42	222	28.542*
	High Level	4.57	.49		
I19	Low Level	2.82	.44	222	31.846*
	High Level	4.73	.44		
I20	Low Level	3.29	.73	222	24.517*
	High Level	5.00	.00		
I21	Low Level	2.72	.54	222	23.432*
	High Level	4.32	.46		
I22	Low Level	3.16	.61	222	21.599*
	High Level	4.73	.44		
I23	Low Level	3.22	.70	222	20.046*
	High Level	4.77	.41		
I24	Low Level	2.71	.54	222	24.701*
	High Level	4.46	.50		
I25	Low Level	2.36	.70	222	24.274*
	High Level	4.30	.46		
I26	Low Level	2.12	.68	222	27.623*
	High Level	4.23	.42		
I27	Low Level	2.18	.62	222	28.546*
	High Level	4.16	.36		
I28	Low Level	2.69	.55	222	24.050*
	High Level	4.38	.48		
I29	Low Level	2.59	.61	222	27.195*
	High Level	4.61	.48		

I25	Low Level	2.36	.70	222	24.274*
	High Level	4.30	.46		
I26	Low Level	2.12	.68	222	27.623*
	High Level	4.23	.42		
I27	Low Level	2.18	.62	222	28.546*
	High Level	4.16	.36		
I28	Low Level	2.69	.55	222	24.050*
	High Level	4.38	.48		
I29	Low Level	2.59	.61	222	27.195*
	High Level	4.61	.48		
I30	Low Level	2.54	.58	222	25.815*
	High Level	4.43	.49		
I31	Low Level	2.70	.54	222	23.922*
	High Level	4.37	.48		
I32	Low Level	2.70	.49	222	30.611*
	High Level	4.68	.46		

**p*<.01*

Results of Item-total Test Correlation Analysis

Factors and Items	$\bar{X}$	S	Item-total correlations	Cronbach's alpha, if item excluded
Factor 1: Learning Goal Orientation (α = 0.90)				
I1	4.18	0.85	.53	.910
I2	4.02	0.87	.68	.900
I3	4.15	0.79	.74	.895
I4	4.38	0.72	.72	.897
I5	4.22	0.82	.76	.892
I6	4.14	0.78	.77	.892
I7	4.34	0.73	.73	.896
I8	4.14	0.80	.68	.900
Factor 2: Task Value (α = 0.89)				
I9	3.69	0.85	.63	.878
I10	3.72	0.89	.66	.878
I11	4.18	0.78	.64	.881
I12	4.00	0.85	.75	.870
I13	3.40	1.02	.60	.886
I14	3.69	0.88	.65	.880
I15	3.67	0.91	.66	.878
I16	3.98	0.88	.70	.874
Factor 3: Self-Efficacy (α = 0.87)				
I17	3.96	0.69	.50	.860
I18	3.81	0.74	.47	.866
I19	3.87	0.77	.51	.860
I20	4.22	0.79	.48	.861
I21	3.55	0.75	.33	.876
I22	3.99	0.67	.55	.855
I23	4.01	0.68	.52	.857
I24	3.59	0.81	.36	.873
Factor 4: Self-Regulation (α = 0.86)				
I25	3.36	0.89	.48	.847
I26	3.19	0.91	.53	.844
I27	3.17	0.84	.36	.849
I28	3.58	0.79	.40	.847
I29	3.64	0.90	.38	.844
I30	3.55	0.86	.56	.830

Factor 4: Self-Regulation (α = 0.86)				
I25	3.36	0.89	.48	.847
I26	3.19	0.91	.53	.844
I27	3.17	0.84	.36	.849
I28	3.58	0.79	.40	.847
I29	3.64	0.90	.38	.844
I30	3.55	0.86	.56	.830
I31	3.57	0.79	.42	.850
I32	3.77	0.84	.52	.836