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The Effect of Entrepreneurship-Based STEM Education on Secondary School Students' Self-Regulation Skills*

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Abstract. This research was carried out to determine the effect of entrepreneurship-based STEM education on secondary school students' self-regulation skills. The sample of the study consisted of 20 students studying in the 8th grade in the 2019-2020 academic year. A single group pre-test-post-test model was used in the study. "Perceived Self-Regulation Skills Scale" was used to obtain quantitative data. Pre-and post-test means of quantitative data were compared by paired-sample t test. Entrepreneurship-based STEM education was provided to the students for 8 weeks. As a result of the research, there was no significant difference between the pre-and post-test scores of the students' self-regulation skills, however, there was an increase in favor of the post test regarding the the concept of self-efficacy and the sub-dimensions of self-regulation skills, called "openness" and "seeking".

Keywords: Secondary school students, self-regulation, STEM activities.

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1. INTRODUCTION

Besides environmental factors, individuals' own capacities are also effective in shaping their own behavior (Sanders & Mazzucheli, 2013). Albert Bandura suggested that individuals personally shape their own behaviors by observing people at a young age. According to Bandura (1991), human behavior cannot be controlled only by external stimulants, reinforcement or punishment. People have the ability to regulate and control their own behavior. Therefore, the characteristics of individuals appear to be an effective factor in the process of behavior control. Self-regulation is one of the characteristics that an individual must have in the acquisition and maintenance of behaviors (Sniehotta, 2009). According to many researchers, self-regulation is a skill that includes the characteristics of individuals as to the control of their own mind, emotions and actions (Booekaerts & Cascallar, 2006; Boekaerts et al., 2005). In other words, self-regulation is a motivational concept that aims to achieve self-goals (Efklides, 2008). Vohs and Baumeister (2004) define self-regulation as "the effort of the personality to change its internal states or reactions". The large majority of studies agree that self-regulation is a general structure that can explain many areas of human functioning (Kauffman, 2004). Besides, this concept and individual variables include different self-processes through which the individual interacts with the environment. Therefore, self-regulation cannot occur without an individual's interaction with the environment (Dinsmore et al., 2008). Self-regulation can be regarded in the academic context as the process of self-management in which students transform their cognitive abilities into academic skills (Zimmerman, 1998). Actions such as setting goals to renovate knowledge, discussing on progress towards goals and setting strategies, and taking the necessary steps to complete tasks, etc. are discussed in the context of the self-regulation process (Butler & Winne, 1995). These actions also indicate that self-regulation, which includes behavioral regulation, is a skill that directly affects the learning process of individuals (Zimmerman & Paulsen, 1995). Because, learning can also be defined as a relatively permanent change in an individual's behaviour (Barron et al., 2015) and, self-regulation skills are required (Hall & Fong, 2007) for behavioural change.

When it comes to the studies on self-regulation skills, it can be seen that the experimental studies are mostly carried out via the participation of younger age groups. Thus the habits and responsibilities that are essential to be acquired in primary school periods such as literacy, doing home assignments, preparing portfolios have been investigated and the impacts of these factors have been examined through experimental and correlational methods. Ramdass and Zimmerman (2011) have suggested that there is a positive correlation between self-regulation skills and doing home assignments, and on the other hand Fuhs et al. (2013) have examined the relationship between the process spent in preschool classrooms and children's acquisition of cognitive self-regulation skills and consequently it was found that cognitive self-regulation skills could be promoted by the teacher approval on student behavior, teachers' emotional approach, the instructional time devoted to literacy and Mathematics and the quality of the educational process. Uzuntiryaki-Kundakçı and Çapa-Aydın (2013) investigated the correlation between

critical thinking skills and self-regulation skills, however, it was concluded that there was no significant difference between these two skills. In addition, Graham and Harris (2000) have suggested that self-regulation skills also affect the development of writing skills. Considering the studies concerning self-regulation, many factors that affect self-regulation skills or self-regulation skills have been presented (Pintrich & Zusho, 2002; Baumeister & Heartherton, 1996; Matthews et al., 2009). In addition to these factors, education has a crucial role in acquisition of self-regulation skills (Leon et al., 2015). STEM education which has been a current issue in recent years was taken as a basis in this study in order to reveal how effective this role is. STEM is an educational approach in which the fields of Science, Technology, Engineering and Mathematics are integrated with daily life (Gonzalez & Kuenzi, 2012). STEM education brings these different fields together and provides multi-dimensional learning with an interdisciplinary approach (Smith & Karr-Kidwell, 2000). STEM is also an educational approach that aims to enable students to acquire problem solving skills using their creativity, to be open to communication and to have ethical values (Karakaya & Avgin, 2016). STEM approach has different models within itself (Caldwell, Garcia, & Cagle, 2018). One of these models is called the "E-STEM model" (Deveci et al., 2015).

The E-STEM model aims to integrate entrepreneurship with STEM education and to provide individuals with entrepreneurial skills through the STEM approach (Rae & Melton, 2017; Caldwell et al., 2018). Entrepreneurial individuals have the characteristics of self-recognition, being goal-oriented and diligent, and providing internal control (Baran et al., 2016). Besides entrepreneurial individuals, also self-regulated individuals have the ability to control their own behavior and have the motivation to work to achieve their goals. Therefore, it is considered that the E-STEM model may have an impact on self-regulation skills as well as entrepreneurial skills. This research is considered to be important in terms of focusing on the impact of STEM education on self-regulation skills due to the fact that the number of studies examining the effect of STEM education on self regulation skills is relatively limited (Kaya, 2018; Akpınar, 2018) contrary to the number of STEM related studies on other high-level skills such as problem solving, critical and creative thinking, inquiry learning (Çakır, 2018; Öztürk, 2018; Topsakal, 2018; Aydın, 2019; Özkızılcık & Cebesoy, 2020). In addition, as the foundations of the educational philosophy adopted after 2013 are based on the "Constructivist Approach", the individual characteristics of students has started to attract more attention. Self-regulation is one of these skills that mostly stand out. Although there has been an emphasis on self-regulation skills in recent years, studies on self-regulation skills are limited in the national literature (Aydın & Ulutaş, 2017). Moreover, many psychologists and educational experts articulate that self-regulation skills have a positive impact on children's success, self-satisfaction and well-being. In addition, individuals are expected to act confidently, to be aware of themselves, to plan their behaviors and actions, and to be oriented towards their goals in order to achieve accomplishments in society (Ablard & Lipschultz, 1998). These expected features are closely related to self-regulation skills, and it is of great importance for individuals to acquire these skills (Cohen, 2012). Since self-regulation skills require

discipline, determination and planning, the acquisition of these skills from an early age is considerably important for students (LaRose et al., 2003). Besides, the importance of self-regulation skills should not be ignored because of the fact that self-regulation is effective in terms of keeping students' attention, behavior and feelings under control and contributing to the students' academic achievement (de Acedo Lizarraga et al., 2003). As a matter of fact, Dignath and Buettner (2008) have conducted a study on the relationship between academic achievement and self-regulation skills and consequently, it has been found that self-regulation skills of primary school students significantly increase primary school students' academic achievement. In addition to academic achievement, self-regulation plays a key role in terms of its contribution to time management, setting goals, completing difficult tasks and achieving a successful position in students' career in the future (Ramdass & Zimmerman, 2011; Zimmerman, 1998). Considering all these reasons, it is believed that it is significant to develop self-regulation skills and to conduct studies on the factors that affect self-regulation. Therefore, the study aims to investigate the effect of entrepreneurship-based STEM education on secondary school students'self-regulation skills.

2. METHOD

Research Design

In this study "a single-group pretest-posttest design" was used to examine the changes in pre and post scores. The universe of the study consists of 20 8th-grade secondary school students being educated in a rural area. The research was conducted in the fall and spring semesters of the 2019-2020 academic year. Purposive sampling technique was used in sample selection. The purposive sampling technique is the deliberate choice of the researcher due to its qualities (Tongco, 2007). The purposive sampling method is the determination of the study sample based on specific objectives or qualities (SA et al., 2021). The qualities considered in this research are "homogeneity" and "convenience". Purposive sampling method enables the sample selections including groups that are easily accessible (Nartgün & Kaya, 2016) and homogenous in terms of age, culture, and socio-economic status (Etikan, 2016). Students in the experimental group were given STEM education which includes entrepreneurship-based STEM activities for 8 weeks. Research data were collected using a quantitative measurement tool before and after the application. The ethics committee approval for this study was obtained from the Ethics Committee of the Human Research Ethics Committee of Erzincan Binali Yıldırım University, dated 04/10/2019 and numbered 10/03.

Data Collection Tools and Analysis

"Perceived Self-Regulation Scale" developed by Arslan and Gelişli (2015) was used in order to collect the quantitative data of the study. This scale was a five-point Likert-type one including strongly agree, agree, don't know, disagree and strongly disagree choices and applied to students before and after the experimental application.

"Paired samples t test" which is one of the statistical methods was used for the analysis of quantitative data. Paired samples t-test is an analysis method that is used in the application of a test-retest situation and in the process for investigating the relationship or the level of difference between pre-test and post-test scores (Mee & Chua, 1991).

Implementation

STEM education was given to the students in the experimental group for 8 weeks by the applications involving entrepreneurship-based STEM activities each week within the scope of the application process. Research data were collected by using a quantitative measurement tool. The studies on the entrepreneurship-based STEM education were examined and the STEM activities were performed by considering the developmental levels and readiness of the experimental group. The "E-STEM" model which was discussed and explained by Deveci in the book called "STEM Education from Theory to Practice" was taken as basis in the application steps of the activities that are economical in terms of time and cost. In this regard, the acquisitions for "the catapult" activity were determined under the name of "Science, Engineering and Entrepreneurship Practices" and the necessary theoretical information about this activity was provided to the students. Then, they were expected to define the problem by associating it with a need in daily life. A discussion and brainstorming environment was created, for instance; "Let's assume there is a problem such as throwing an object away. So how would we deal with this problem?". Afterward, students were given the chance to answer the question "What kind of design can we develop to solve this problem?" and subsequently, they were asked to choose the simple materials with which they could model this design. Each group of students discussed how effective the work was in solving the given problem by designing their joint work, and also the questions "What variables must be changed? (For example, if the rubber bands are wrapped more in the tongue bar, the object can be thrown further? etc.)" were asked by the students and they argued on which principles of STEM fields that they used to develop this work.

3. FINDINGS

The Analysis of Quantitative Data

The quantitative data of the study were analyzed by statistical methods. It is observed that the obtained quantitative data are normally distributed by considering Shapiro-Wilk due to the fact that the sample number was below 50 (Razali and Wah, 2011). According to the Shapiro-Wilk test, a p-value higher than 0.05 (> 0.05) indicates that the data group is normally distributed (Taşpınar, 2017). The pre-and post-test results of the "Perceived Self-Regulation Scale" and its sub-dimensions applied to 20 students before and after the implementation were analyzed with the "Paired Sample t-test" method. The findings obtained are shown in Table 1 and Table 2.

Table 1

Results of the Paired Sample t-Test

Measurements	N	x̄	sd	t	df	p
Pre-test	20	59.65	12.30	-.751	19	.462
Post-test	20	62.40	8.88			

The paired sample t-test results of the pre and post test scores of students' self-regulation skills are shown in Table 1. Paired samples t-test was conducted to determine whether there was a significant difference between pre-test and post-test scores. Since the significance level was higher than 0.05 (p> 0.05), no significant difference was found between pre-post scores.

Table 2

Results of the Paired Sample t-Test for sub-dimensions

Sub-dimension	Measurements	N	x̄	sd	t	df	p
Openness	Pre-test	20	30.75	6.33	-.089	19	.572
	Post-test	20	30.90	4.18			
Seeking	Pre-test	20	28.90	7.10	-1.134	19	.271
	Post-test	20	31.50	5.38			

The paired sample t-test results of the pre and post-test scores of the sub-dimensions are shown in Table 2. Since the significance level is higher than 0.05 (p> 0.05) for both sub-dimensions, it can be stated that there is no significant difference between pre-post scores.

4. RESULTS, DISCUSSIONS AND SUGGESTIONS

The aim of the study was to determine the effect of entrepreneurship-based STEM activities on secondary school students' self-regulation skills. Considering the quantitative findings, it was concluded that there was an increase in favor of the post-test, however this increase was not significant. In other words, in the quantitative analyzes of the study, there was no significant difference in pre-test and post-test scores of the self-regulation. However, according to the results obtained from the self-regulation scale the self-regulation post-test score is higher than the pre-test score. Concerning the sub-dimension of the scale called "openness", which includes items related to noticing innovations and getting help from others, it was concluded that there was an increase in

favor of the post-test, despite the fact that the pre and post test scores were quite close to each other. The reason for this result may be that the students gained a new perspective and the opportunity to learn new conditions and experiences they were not acquainted before. The fact that students encountered new situations and experienced a faster learning process can be given as one of the reasons that affect this result.

The features expressed in the "openness" are also associated with the concept of self-efficacy. Because, self-efficacy is a concept that expresses the belief of an individual to be able to do any skill or ability (Bandura, 2010). The data obtained from the current studies support this correlation as well. Arseven (2016) argued that the concept of self-regulation is related to self-efficacy. Tortop and Eker (2014) found that there is a relationship between pre-service teachers' self-efficacy beliefs and self-regulation skills. Schunk (1994) also mentioned the existence of this correlation in one of his studies. In addition, the study conducted by Chularut and DeBacker (2004) indicated that there is a connection between self-regulation and self-efficacy skills, as the concept mapping technique increases both self-regulation and self-efficacy skills of students. Another finding of the study is that concerning the sub-dimension called "seeking", a higher increase was found compared to the "openness". The "seeking" includes items related to organizing and following the individual's own behavior, finding different alternatives, and problem solving. Therefore, it was observed that these skills of the students were more inclined to change after the implementation. It can be inferred from these consequences that STEM activities could have more impact on the characteristics related to these behavioral changes.

Singh et al. (2018) stated that heuristic learning is an important requirement for STEM students. This result, which is associated with the concept of "seeking" also supports the quantitative analysis result. Lowrie et al. (2018) suggested in a study that STEM applications could play a contributing role in heuristic thinking. All these results show that STEM activities contribute to students' learning processes in terms of using a different alternative. Also, the emergence of this situation was caused by the fact that the students handled with various exploratory processes in STEM activities, and they reached the conclusion thanks to the trial and error method without knowing what the correct solution was in advance, thus, the activities helped them acquire a different learning method.

This study concluded that STEM activities had no significant impact on self-regulation skills. Despite the fact that, in some of the previous studies, it was observed that STEM activities had a significant effect on self-regulation skills (Kaya, 2018; Akpınar, 2018). Üredi and Erden (2009) asserted that parent attitude is an important predictor of self-regulation skills. Therefore, it can be concluded that the change in self-regulation skills depends not only on the practices, but also on familial and environmental factors. Another study supporting this idea was conducted by Jouhari et al. (2015), and they pointed out that the personality, family, peer environment, and educators are the main factors affecting self-regulation skills. Additionally, the fact that the duration of the activity was

limited to 8 weeks can be given as one of the reasons why the activities did not significantly affect self-regulation skills or their sub-dimensions (openness, seeking).

Based on the research results, the following recommendations have been developed for future studies; 1) application time can be extended, 2) larger samples can be selected, 3) the effect of different educational approaches on self-regulation skills can be investigated and 4) conducting studies simultaneously at different levels can contribute to attaining more generalizable results.

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