European Journal of Education Studies
ISSN: 2501 - 1111
ISSN-L: 2501 - 1111
Available on-line at: www.oapub.org/edu

doi: 10.5281/zenodo.3731131 Volume 7 | Issue 2 | 2020

ANALYSIS OF SELF-EFFICACY BELIEFS FOR SCIENTIFIC LITERACY OF THE SEVENTH-GRADE STUDENTS WITH DIFFERENT COGNITIVE STYLES

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Abstract:
The objective of this study is to ascertain whether there is a significant difference between self-efficacy beliefs for scientific literacy of the seventh grade students having field dependent and field independent cognitive styles and to find out whether the cognitive style of students is a significant predictor of students' self-efficacy beliefs for scientific literacy. Benefiting from correlational survey model, a quantitative research method, the study which is addressed to a sample composed of 823 seventh grade students enrolled in Ankara in the school year of 2015-2016. Scientific Literacy Self-Efficacy Scale was used in order to find out students' self-efficacy beliefs for scientific literacy whereas Group Embedded Figures Test was utilized in order to ascertain whether students had field dependent or field independent cognitive styles. In the research, it was discerned that the cognitive style is a statistically significant predictor of students' self-efficacy beliefs for scientific literacy ($R2=0.04, F(1.821)=29.30, p<.00$). Besides, it was found that there was a statistically significant difference in the mean of scores of self-efficacy beliefs for scientific literacy of field dependent, moderately field dependent and field independent students in favor of field independent students [$(F(2.822)=13.61; p<.05$]. Based on the results obtained from the research, it is thought that efforts to analyze the characteristic features of students with different cognitive styles, teaching environments convenient for these students and measurement & evaluation approaches will help to raise students as scientifically literate individuals.

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Keywords: self-efficacy beliefs for scientific literacy, field dependent-field independent cognitive styles, scientific literacy, science education

1. Introduction

Raising the students as scientifically literate individuals remained to be among the basic goals of science educators for a long time. Even so, the vision of science teaching program of several countries including but not limited to Turkey is to raise all students as scientifically literate individuals (Liu, 2009). As one of the basic variables of social cognitive learning theory, self-efficacy is defined as individuals' beliefs in skills to organize and fulfill actions necessary for reaching a desired performance. Moreover, it can be described as a concept for specifying how much effort to be made by the individual in order to achieve in carrying out a behavior and for how long the individual will persist in doing this behavior if confronted with a problem (Bandura, 1997). According to the theory, self-efficacy beliefs of individuals are developed through four ways, that is to say, by means of (i) experiences of individuals, (ii) social modeling, (iii) social perception of the environment and (iv) reduction of stress and depression (Bussey & Bandura, 1999). Several studies revealed that individuals' self-efficacy belief in a specific field was a significant variable predicting their success in that field (Aktamıs, Kiremit & Kubilay, 2016; Juan, Hannan & Namome, 2018; Multon, Brown & Lent, 1991; Schunk & Zimmerman, 2003, p.446; Inaltun & Ates, 2015; Velayutham et al., 2011). In the meta-analysis performed by Multon, Brown and Lent (1991) and covering findings of 36 studies on self-efficacy, it was asserted that self-efficacy beliefs explained 14% of the variance in the academic performance of students. Effect size of the self-efficacy for these studies was also reported as 0.38, which is categorized as large effect size. The common view in the literature is that there is a statistically significant positive relationship between self-efficacy beliefs of students and their academic performance.

Self-efficacy which is the individual's belief in his/her skill in achieving a duty is a crucial factor for enhancing academic accomplishment. If a student feels that he/she will fail in the course, his/her motivation and concentration skills necessary for understanding the subject are likely to go down. Therefore, attention is drawn to the concept of self-efficacy in education. It is indispensable for teachers and educational programmers to understand how they will develop students' self-efficacy beliefs in the positive direction. Besides, considering that self-efficacy belief in a specific field is a significant variable predicting the success in that field, it is essential to identify individual differences affecting students' self-efficacy beliefs in scientific literacy (Fives, Huebner, Bırnbaum & Nicolich, 2014).

One of the most common fields of research on individual differences pertains to cognitive styles of individuals. Saracho (1988) defines the cognitive style as individuals' way of processing knowledge whereas Bagley (1988) defines it as "*persons' manner of perception, interpretation, organization and thinking of themselves in terms of their environments*". In the most general sense, cognitive style is defined as characteristic

features specifying the manner in which the knowledge in the external world is inserted into the memory, processed, stored and used in the memory. Both theoretical and experimental studies on cognitive styles were conducted for a long time. Along with these researches, several categorizations about cognitive styles of individuals were developed (Messick, 1984). Even though there exist different categorizations about cognitive styles, it is discerned that all categorizations have basically analogous characteristics. Basic characteristics of cognitive styles present in all categorizations pertain to their process-oriented makeup, holistic structure affecting all activities performed by individuals, stability across time and bipolar structure (Witkin, Moore, Goodenough & Cox, 1977). The most common categorization used in the literature is the one based on the field dependence and field independence of cognitive styles. Witkin and Goodenought (1981) define field dependence and field independence aspect of cognitive styles as the individual's inclination to be affected in his/her activities in cognitive and social fields more or less by the external foundation of perception. Field independent individuals are less under the influence of external stimulus than dependent individuals while analyzing the complicated structure of the field in which they are involved and also while finding and extracting a specific element from a complicated whole. Field dependent individuals pay attention to external stimulus which exerts influence on their perceptions whereas field independent individuals attach importance to internal stimulus rather than external stimulus. Another difference between two cognitive styles pertains to the way of instilling knowledge into the memory. Field independent individuals receive knowledge from external world by breaking the knowledge apart, in other words, by analyzing it whereas field dependent individuals acquire the knowledge as a whole. The most obvious and crucial difference between two cognitive styles pertains as to how the incoming knowledge is structured in the memory. If there is an incoming knowledge, field independent individuals initially arrange, organize, restructure and make the knowledge compatible with their own schemes and then insert it into their own existing schemes. On the other hand, field dependent individuals accept the incoming knowledge as it is without restructuring it (Jonassen & Grabowski, 1993).

The review of literature demonstrate that field dependence and field independence cognitive style is one of the most powerful predictors of academic success (Terrell, 2002, Sahin, 2018). In the collected work by Tinajero and Paramo (1998), it was declared that field independent students from across all disciplines (physical sciences, social sciences, language sciences) were more successful. In a study by Smith (2002), it was argued that field independent students selected areas of study necessitating cognitive skills whereas field dependent individuals preferred areas of study requiring interpersonal communication skills (p. 65). In the meta-analysis performed by Baker and Dwyer (2005) on the relationship between teaching strategies and individual differences, it was suggested that field independent learners got higher scores from achievement tests whereas field dependent learners did better in classical type of exams (p. 78). In the literature, there exist several studies analyzing the relationship between field dependent and field independent cognitive style structure and success in the science (Kirk, 2000;

Bahar & Hansell, 2000; Bahar, 2003; Karacam, 2005; Tsaparlis, 2005; Danili & Reid, 2004, 2006; Horzum & Alper, 2006; Ongun, 2006; Ates & Cataloglu, 2007; Hindal, Reid & Badgaish, 2009; Altınparmak, 2009; Çelik, 2010; Karacam & Ates, 2010; Sarı, Altınparmak & Ates, 2013; Cataloglu & Ates, 2013; Morris, Farran & Dumontheil, 2019; Ozarslan & Bilgin, 2016; Obianuju, 2012; Onyekuru, 2015; Muhammad, Daniel & Abdurauf, 2015; Okoye, 2016). In these studies, field independent students are generally more successful in science than field dependent students. The review of these studies indicates that success of students in science is defined mostly as the problem-solving skill.

As self-efficacy belief in scientific literacy is assumed to have effect on scientific literacy, it is considered that variables likely to affect self-efficacy belief in scientific literacy are also supposed to have an indirect effect on scientific literacy level. In this situation, the analysis of self-efficacy beliefs in scientific literacy of students with different cognitive styles is essential to ensure that these students are raised as scientifically literate individuals. Even though individuals' self-efficacy belief in any field was a significant variable predicting their success in that field, there was no previous study analyzing individuals' self-efficacy beliefs in scientific literacy in terms of field dependent and field independent cognitive styles. It is thought that analysis of the relationship between these variables is likely to help to explain scientific literacy of students inasmuch as it is essential to promote success by making use of the characteristic features of field dependent and field independent cognitive styles and to acquire information as to how to create the best learning environment by placing the focus on the self-efficacy of each student in the class. Therefore, this research aimed to ascertain whether there was a statistically significant difference between self-efficacy beliefs in scientific literacy of the seventh-grade students with field dependent and field independent cognitive styles and to find out whether the cognitive style of students was a significant predictor of students' self-efficacy beliefs in scientific literacy.

In conjunction with this objective, sub-problems of the study are as below:

1) Is the cognitive style of students a significant predictor of students' self-efficacy beliefs in scientific literacy?
2) Is there a statistically significant difference between self-efficacy beliefs in scientific literacy of field-dependent, moderately field-dependent and field-independent cognitive styles seventh grade students

2. Material and Methods

In this part, the research model which is employed in the study, research population and research sample, data collection tools, data collection process and data analysis will be addressed.

2.1 Research Model

The research was designed on the basis of correlational survey model which is a general research model. This model is utilized in order to identify whether there is a statistically

significant relationship between multiple variables, and to ascertain the magnitude of this relationship if there is any statistically significant relationship (Karasar, 2012, p. 77).

2.2 Population and Sample

The research population covered the seventh-grade students studying in Altındag, Cankaya, Etimesgut, Mamak, Pursaklar, Yenimahalle and Keciören districts of Ankara province, Turkey. The research sample was composed of a total of 823 seventh-grade students studying in aforementioned districts of Ankara in the school year of 2015-2016. This sample was created through stratified sampling. For this purpose, firstly, the population was divided into representative sub-units, then, elements were sampled from each sub-unit. Sampling of elements from sub-units was carried out on the basis of the relative proportion of each sub-unit in the total population (Fraenkel, Wallen & Hyun, 2012). In this research, districts of downtown Ankara were selected as sub-units of the population. The number of students to be included into the sample from each district of downtown Ankara was specified in light of the proportion of students studying in each district to the total population. In this respect, 91 students from Altındag district, 124 students from Cankaya district, 88 students from Etimesgut district, 197 students from Keciören district, 122 students from Mamak district, 77 students from Pursaklar district and 124 students from Yenimahalle district participated in the study. Table 1 exhibited numbers of students participating in the research by district and by gender.

Table 1: Breakdown of Students in the Sample by District

	Yenimahalle	Keciören	Etimesgut	Mamak	Altındag	Cankaya	Pursaklar	Total
Female	75	105	50	68	46	63	39	446
Male	49	92	38	54	45	61	38	377
Total	124	197	88	122	91	124	77	823

Table 1 shows that 446 (52%) of students participating in the study were females whereas 377 (46%) of participants were males.

2.3 Data Collection Tools and Process

In order to find out the level of students' self-efficacy beliefs in scientific literacy, Scientific Literacy Self-Efficacy Scale was used. This scale is a sub-scale of Scientific Literacy Assessment measure which was developed by Fives et al. (2014) in order to ascertain the level of scientific literacy of students. Its format in Turkish was created by researchers (Sahin & Ates, 2018). Through confirmatory factor analysis performed with data collected while creating the Turkish format, it was discerned that the relationship was statistically significant as the p-value for the chi-square test was less than 0.05 ($\chi2$= 32.96, N=500, sd=20, p=0.00, ($\chi2$/sd)=1.65, RMSEA=0.04, CFI=0.98, TLI=0.97, SRMR=0.03). Cronbach's Alfa coefficient was found to be 0.77 for the test.

In order to find out whether students had field dependent and field independent cognitive styles, group embedded figures test was utilized (Witkin Oltman, Raskin & Karp, 1971). This is the most commonly used test in this area (Pithers, 2002). It was

developed to measure the level of field dependence of each participant. In the test, participants are required to identify the simple geometric figures from among complicated geometric figures in a specific period of time. The Turkish format of the test was created by Cakan (2003) and Cronbach's Alfa coefficient measuring its reliability was reported to be 0.82. Upon DFA (Detrended Fluctuation Analysis) performed to test the construct validity of group embedded figures test through data collected in this study, it was discerned that the relationship was statistically significant as the p-value for the chi-square test was less than 0.05 (χ2= 396.83, N=804, sd=135, p=0.00, (χ2/sd)=2.93, RMSEA= 0.05, CFI=0.98, TLI=0.97,WRMR=1.28). These values show that data are highly compatible with the model. Kuder-Richardson (KR-20) reliability coefficient was found to be 0.89 for the group embedded figures test. These findings obtained in relation to both measurement tools indicate that these measurement tools have construct validity and reliability at satisfactory level (Hu & Bentler, 1999; Kline, 2005; Schermelleh-Engel, Moosbrugger & Müller, 2003; Yu, 2002).

A formula was proposed for the categorization of students as field independent, moderately field dependent and field dependent (Alamolhodaei, 1996, citing from El-Banna, 1987). According to this formula, students obtaining a score which is more than one fourth of the standard deviation above the mean score are categorized as field independent, students obtaining a score which is more than one fourth of the standard deviation below the mean score are categorized as field dependent and students obtaining a score less than one fourth of the standard deviation above and below the mean score are categorized as moderately field dependent. In this study, the same formula was employed to categorize the students (Alamolhodaei, 1996; Ates & Cataloglu, 2007; Cataloglu & Ates, 2013).

3. Findings

In this part of the research, findings obtained from the analysis of data in the context of sub-problems will be addressed.

Table 2 displays the results of regression analysis for identifying the predictive effect of cognitive styles of seventh grade students on their self-efficacy beliefs in scientific literacy.

Table 2: Results of Regression Analysis Conducted for Predicting the Variable of Self-Efficacy Beliefs in Scientific Literacy

Variables	B	Standard Error	B	*T-value*	*p-value*
Constant	29.46	0.29		101.75	0.00
Cognitive Style	0.17	0.03	.19	5.41	0.00

The review of Table 2 indicates that cognitive style is a statistically significant predictor of participants' self-efficacy beliefs in scientific literacy (R^2= 0.04, F(1,821)= 29.30, p< .00). According to the results of regression analysis, the predictive effect of participants'

cognitive styles on their self-efficacy beliefs in scientific literacy is in the moderate effect category ($\beta = .19$, $p<.001$) (Kline, 2005, p.122).

Table 3 displays the results of descriptive statistics created for analyzing whether there was a difference between scores of self-efficacy beliefs in scientific literacy of students with field dependent, moderately field dependent and field independent cognitive styles and also indicates variance analysis performed to examine whether this difference was statistically significant.

Table 3: Descriptive Statistics and ANOVA Results for Self-Efficacy Beliefs in Scientific Literacy on the Basis of Cognitive Styles

Group			$\overline{X}$	***Std. Deviation***	***N***
Field Independent			31.74	0.27	264
Moderately Field Dependent			31.13	0.33	187
Field Dependent			29.93	0.23	372
Source	**Sum of Squares**	**Sd**	**Mean Square**	***F***	****p***
Inter-group	540.03	2	270.02	13.6	.00
Intra-group	16272.04	820	19.84		
Total	16812.07	822			

The review of descriptive statistics in Table 3 for students' self-efficacy beliefs in scientific literacy on the basis of cognitive styles (field dependent, moderately field dependent, field independent) show that mean scores and standard deviation values of students' self-efficacy beliefs in scientific literacy are successively 31.74 and 0.27 for field independent students, 31.13 and 0.33 for moderately field dependent students, and 29.93 and 0.23 for field dependent students.

According to the results of variance analysis in Table 3, it was found that there was a statistically significant difference between cognitive styles of students and their self-efficacy beliefs in scientific literacy [F (2,822) = 13.61; $p<.05$.]. In order to discern between which groups there was a statistically significant difference, Scheffe test was utilized. Results of this test are exhibited in Table 4.

Table 4: Mean Differences in Scores of Self-Efficacy Beliefs in Scientific Literacy on the Basis of Cognitive Styles and Results of Multiple Comparisons

Comparison	**Mean Difference**	**s.e.**	**95% CI**
Field dependent-Moderately field dependent	-1.21*	0.39	-2.19, -0.23
Field dependent-Field independent	-1.82*	0.36	-2.70, -0.94
Field independent-Moderately field dependent	-0.61	0.43	-0.44, 1.65

* $p < .05$, where p-values are adjusted using the Scheffe method.

Table 4 demonstrated that there was a statistically significant difference between means of scores of self-efficacy beliefs in scientific literacy of field independent students and field dependent students in favor of field independent students. Moreover, it was found that there was a statistically significant difference between means of scores of self-efficacy

beliefs in scientific literacy of moderately field dependent students and field dependent students in favor of moderately field dependent students ($\overline{X}_0$=31.74, $\overline{X}_1$= 31.13, $\overline{X}_2$ =29.93). However, there was no statistically significant difference between means of scores of self-efficacy beliefs in scientific literacy of field independent students and moderately field dependent students. In this study, effect size (eta squared) was found to be 0.03. According to Cohen (1985), this value is within the small effect category. This situation shows that 0.3% of the variance of scores of students' self-efficacy beliefs in scientific literacy arises from differences between cognitive styles of students.

4. Results, Discussion and Recommendations

Findings of this research indicate that the variable of field dependent/field independent cognitive style is a statistically significant predictor of self-efficacy beliefs in scientific literacy of the seventh-grade students. These results are compatible with findings of studies in the literature (Sahin, 2018; Muhammad, Daniel & Abdurauf 2015; Morris, Farran & Dumontheil, 2019). In the study by Morris, Farran and Dumontheil (2019), it was suggested that there was a statistically significant relationship between the level of field dependence of students who were in the early childhood period and their success in science. The study by Şahin (2018) was conducted with the participation of the seventh-grade students, and it was found that field dependent/field independent cognitive style was a statistically significant predictor of scientific literacy performance of students in the construct model explaining the level of scientific literacy of students. In this study, field dependent and field independent cognitive styles even explained 20% of the variance in scientific literacy directly. Research by Muhammad, Daniel and Abdurauf (2015) was performed with the participation of university students, and cognitive style explained 10% of the variance in the success in biology in the research. However, in this current research, even though cognitive style of field dependence and field independence was a statistically significant predictor of self-efficacy beliefs in scientific literacy of students, it explained just 0.4% of the variance. It is thought that this situation arose from the fact that self-efficacy belief was a perceptual variable.

In conjunction with the categorization of students into groups in terms of field dependence, another crucial finding of the research is that, as students' field independence increases, there is likely to be growth in their self-efficacy performance. This finding of the research coincides with findings of other researchers analyzing the relationship between cognitive style of students and success in science (Kirk, 2000; Bahar & Hansell, 2000; Bahar, 2003; Karacam, 2005; Tsaparlis, 2005; Danili & Reid ,2004, 2006; Horzum & Alper, 2006; Ongun, 2006; Ates & Cataloğlu, 2007; Hindal, Reid & Badgaish, 2009; Altınparmak, 2009; Celik, 2010; Karacam & Ates, 2010; Sarı, Altınparmak & Ates, 2013; Cataloğlu & Ates, 2013; Obianuju, 2012; Onyekuru, 2015; Okoye, 2016; Ozarslan & Bilgin, 2016). This research addressed the effect of students' cognitive styles on self-efficacy beliefs in scientific literacy whereas other cited researchers analyzed the effect of students' cognitive styles on the success in science. It is believed that enhancing the self-

efficacy beliefs in scientific literacy of students with different cognitive styles will likely help to reduce the difference in the level of scientific literacy of these students.

Results of the research demonstrate that students' cognitive style type on the basis of field dependence has a significant effect on students' self-efficacy beliefs in scientific literacy. Considering the fact that the concept of self-efficacy is a significant variable predicting the success in a field, these results turn to be even more substantive because raising scientifically literate individuals is the primary focus of educational programs of quite a few countries including but not limited to Turkey. Through researches on the effectiveness of teaching methods differentiated on the basis of cognitive styles of students, all students will have the opportunity to explore the subjects and concepts bearing in mind the characteristic features of their own cognitive styles. Researches on the effectiveness of teaching and measurement & evaluation techniques convenient for each cognitive style will help to promote the engagement of students with their learning activities and enable them to be more active in the learning process. That being the case, it is critically important to understand how to devise the teaching in a way to be convenient for characteristic features of cognitive styles of students in order to create a favorable learning environment. In the literature on cognitive styles, characteristic features of students with different cognitive styles, cognitive learning environments for these students and measurement & evaluation approaches were analyzed in detail (Witkin et al., 1977; Saracho, 1997). Teachers should be made aware of obstacles stemming from field dependence of cognitive styles. Organizing materials to be used in the teaching process and simplifying less relevant and complicated contexts in teaching activities on the basis of their order of importance will help the learning process of field dependent students as field dependent students tend to pay attention also to less relevant aspects of a phenomenon. Thus, it is essential for teachers to take organizing steps likely to ensure that students will focus on core ideas when they study their text books or use their teaching materials (Danili & Reid, 2004).

It is pretty hard for field dependent students to distinguish important information from the rest in the multiplicity of information presented in lectures where direct instruction method is implemented. It is relatively easy for field independent students to detect the important information. Moreover, using teaching methods involving more social interaction such as methods based on discussion and cooperation will help to overcome the disadvantage of field dependent students. It is pretty challenging for teachers to apply the teaching method convenient for each individual student in the classroom. However, even the occasional application of different teaching and evaluation techniques by teachers will help to eliminate disadvantages arising from individual differences.

It is important that teachers configure the teaching plan by considering the characteristic features of field dependent and field independent cognitive styles, however, it is also essential to design the teaching materials to be used in lectures on the basis of characteristic features of these cognitive styles. Therefore, it is believed that it is necessary for authors of text books, computer programmers, teaching webpage designers

and instructors to revise teaching materials to be applied in lectures on the basis of the field dependent cognitive style.

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