The effects of field dependent/field independent cognitive styles and motivational styles on students' conceptual understanding about direct current circuits

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Received 10 Jun., 2015
Revised 29 Dec., 2015

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Abstract

The purpose of this study is to investigate the effects of Field Dependent (FD)/Field Independent (FI) cognitive styles and motivational styles on high school students' conceptual understandings about direct current circuit concepts. The participants of this study consisted of 295 high school students (male=127, female=168) who were enrolled in eleventh and twelfth grade in four high school located in Düzce. At the beginning of the study, the Group Embedded Figures Test (GEFT) was administered to identify students' FD/FI cognitive styles. After the administration of GEFT, a questionnaire was administered to determine students' motivational styles. Direct Current Resistive Electric Circuit Test (DIRECT) was administered in order to probe students' levels of conceptual understandings. One-way ANOVA and Post-Hoc Tukey test was used to statistically compare the mean scores of students with different cognitive and motivational styles. The results indicated that there was statistically significant difference among the mean scores of FD students and others (FINT and FI students). In addition, it was found that there was statistically significant difference among mean scores of social motivated students and others (curious, conscientious and achiever student). These results imply that due to traditional approaches in learning environment, some of students are still more advantageous than others in electricity subject in Turkey. We couldn't have managed to enhance the understandings of all students with different abilities, especially of social motivated students.

Keywords: Motivational Styles, Cognitive Styles, Conceptual Understanding, Direct Current Circuit

Introduction

Recent research studies in science education that have investigated the factors influencing science achievement have emphasized some variables such as pre-experiences, individual differences and different assessment techniques. The primary studies focused on the effects of individual differences (especially students' demographical properties like gender and socio-economic level) on science achievement. In majority of these studies, the effect of gender on science achievement was examined. The results of these studies (Gray, 1981; Kelly, 1988; Karaçam, 2005) showed that males are more successful than girls in science, especially in physics. The gap between males and females' science achievement has been explained based on the pre-experiences of male and females and the expectations of different assessment techniques. The variation between the achievements of male and female students on different assessment techniques has been explained based on Different Item Functioning Theory (DIF). The results of DIF studies showed that females are more successful in open ended question formats while males are more successful in multiple choice tests (Karaçam, 2005). Thus, it is asserted that there are some variations between male and females' achievements determined via different assessment techniques due to the different requirements of assessment techniques and the differentiation among abilities of males and females (O'Neil & Brown, 1998). In addition, Johnson (1987) asserted that an important reason of this result is difference between pre-experiences of males and females. According to Johnson, females play with dolls, and are interested in their illnesses and care whereas males generally play with electric circuits and cars, and are interested in motions of things.

Students' pre-experiences about scientific phenomenon are examined by researchers based on cognitive science. In these studies, researchers have examined mental models and conceptual aspects, especially students' misconceptions related to scientific phenomenon. According to those researchers, scientific knowledge about electricity includes much more abstract concepts. Since students might intuitively construct far more alternative concepts based on their experiments about abstract concepts than concrete concepts, they are possessed of some alternative concepts in science, and come to courses with those alternative concepts. Alternative concepts have negative effects on students' learning, and are resistive to altering. Therefore, determining students' alternative concepts is vital to conceptual understanding about scientific phenomenon.

Based on cognitive science, some cognitive variables like cognitive styles were defined as well. Thus, researchers emphasized the effects of FI/FD cognitive styles and motivational styles on science achievement. Related studies about cognitive styles and motivational styles are provided in the next section.

The Relationship between FD/FI Cognitive Styles and Students' Achievements

Cognitive styles were defined in different ways by researchers (Witkin, Moore, Goodenough & Cox, 1977; Witkin & Goodenough, 1981; Green, 1985; Saracho, 1997). However, these definitions have a lot in common. For example, Green (1985) defined cognitive styles as the way which is used for thinking, communicating and perceiving by individuals. Witkin, et. al. (1977) described cognitive styles as the individual differences in ways of thinking, learning, perceiving, problem solving and assimilating the new knowledge. Witkin and Goodenough (1981) indicated that cognitive styles exist and affect the ways of learners' assimilating and processing information and expressing what they know. Saracho (1997) stated that cognitive styles are correlated with attitudes, strategies and preferences that affect individuals' ways of perceiving, problem solving and recalling.

Several researchers have defined cognitive styles with their own perspectives and have improved their own assessment instruments to identify learners' cognitive styles. In this study, we distinguished students' cognitive styles based on the Witkin and Goodenough's (1981) FI/FD dimensions. Learners who are identified as FI/FD cognitive styles have different tendencies about learning, problem solving, perceiving, assimilating the knowledge and recalling. Some characteristics of FI and FD students are presented at Table 1.

Table 1: Some Characteristics of FI/FD Students

Characteristics of FD	Characteristics of FI
FD students might recognize only explicit clues in learning or problem solving environment (Dickstein, 1968). They have a strong tendency towards communicating with people and they are inclined to physical and psychological intimacy. (Witkin ve Goodenough, 1981). They are inclined to be affected by the people around and prefer getting feedback (Leventhal & Sisco, 1996). They prefer group works and follow an emotional and critical approach in their social communication (Chinien & Boutin, 1992/1993). They rely on appearance of the individuals in their social interaction (Riding & Cheema, 1991).	FI students might recognize implicit cules as well (Dickstein, 1968). They aren't inclined to communicating with people and having physical or psychological intimacy with them (Witkin ve Goodenough, 1981). They are less effected by the people around and don't prefer getting feedback (Jones, 1993). They are competitive and prefer individual study (Lyons-Lawrence, 1994) They rely on emotions and thoughts of the individuals in their social interaction (Riding & Cheema, 1991).

In studies related to FD/FI cognitive styles, researchers aimed examining the effects of FD/FI congnitive styles on students' achievements in several disciplines. Alamolhodaei (1996) and Donnaruma, Cox and Beder (1980) studied in math, Ziane (1990), Karaçam (2005), Ateş and Çataloğlu (2007) and Çataloğlu and Ateş (2014) studied in physics and Bahar & Hansell (2000) and Danili & Reid (2006) studied in chemistry. Although these studies were conducted in several disciplines, it was showed that FI/FD cognitive styles are one of the important predictors of student achievement.

The first studies in science and math was conducted by Witkin et al. (1977). As a result of their study, Witkin et. al. indicated that there was a significant correlation between FI/FD cognitive styles and science and math achievement and FI students are more successful than their FD peers in both courses. Similarly result was asserted by Ziane (1990) studied in force and motion subjects. Witkin et. al. (1977) and Ziane (1990) emphasized on differences between FD and FI students' cognitive abilities to explain variation between FI and FD students' science achievements. According to Witkin et. al. (1977) and Ziane (1990), FI students are more successful than FD counterparts in science and math since FI students are better than FD students about distinguishing relevant clues. But Ateş and Çataloğlu (2007) found that there is no statistically significant difference between FI/FD students' scores on Force Concept Inventory (FCI). According to Ateş and Çataloğlu one reason of this result is that FCI doesn't require some skills that favoured FI. Hence, Ateş and Çataloğlu asserted that FCI is not appropriate assessment tool in order to determine the effect of FI/FD cognitive styles due to its structure and style.

By the end of 1990's, researchers began to examine the effect of FI/FD cognitive styles on science achievement based on DIF (Karaçam, 2005; Danili and Reid, 2006; Çataloğlu and Ateş, 2014). The results of these studies indicated that there are relationships among FI/FD cognitive styles, science achievement and format and content of assessment techniques. Karaçam (2005) investigated the effects of FI/FD cognitive styles on students' conceptual understandings about force and motion laws measured by multiple choice, open ended tests and structured communication grid. Karaçam showed that there was a statistically significant mean difference between FD and FI students' conceptual understanding levels about force and motion when they were assessed by using a multiple choice test. On the other hand, there was no statistically significant mean difference between FD and FI students' conceptual understanding levels when they were assessed through an open ended test and structural communication grids. Çataloğlu and Ateş (2014) examined the effect of FI/FD cognitive styles on freshman students' performances related to applications of degrees of naïve impetus theory. Two tier and multiple choice tests were used to determine students' application degrees of naïve impetus theory. When data was analysed, it was found that there were statistically significant correlations between FI/FD cognitive styles and students' application degrees of naïve impetus theory, and that FI students' application degrees were higher than FD students' in both tests. From these findings Çataloğlu and Ateş asserted that some of the factors that affect pupils' performance might be: (a) the content and presentation of the test, (b) the format of the test, and (c) the cognitive difference of the individual like FI/FD (Danili and Reid, 2006).

The Relationship between Motivational Styles and Science Achievement

Some of researchers (Adar, 1969; Hofstein & Kempa, 1985; Kempa & Diaz, 1990a, 1990b; Al-Naeme, 1991; Solomon, 1996) emphasized the importance of the affective dimension, especially motivational style, in terms of individual differences. There are many categorizations about motivation style in the literature. Some of these categorizations have the same dimensions including need and readiness (Bahar, 2002). As an example of these, Adar (1969) categorized students according to their motivational styles based on the predominance of the following needs; i) the need to achieve, ii) the need to satisfy one's curiosity, iii) the need to discharge a duty, and iv) the need to affiliate with other people. Adar referred to the four motivational styles of students as achiever, curious, conscientious and social respectively and described the four groups as follows: Achievers have a distinct preference for an expository method of teaching to enable themselves to achieve well. They compete to be top and get pleasure from excelling. Conscientious students want to be told exactly what to do and enjoy clearly stated objectives. Curious students keep asking why. They have a distinct preference for discovery learning and problem solving activities. Social students enjoy their opinions being heard. They conform to everything easily and like working in groups. They like studying and discussing problems with their friends.

There are some studies based on Adar's categorization of motivational styles (Hofstein & Kempa, 1985; Kempa & Diaz 1990a, 1990b; Johnstone & Al-Naeme, 1995). However, the studies on motivational styles are very limited. Some of these studies (Kempa & Diaz 1990a, 1990b; Bahar, 2003b) emphasized the interaction between gender and motivational styles. Results of these studies generally showed that whereas boys are achiever, girls are conscious.

Another group of studies (Hofstein & Kempa, 1985; Al-Naeme, 1991; Johnstone & Al-Naeme, 1995; Bahar, 2003b) emphasized the effects of motivational styles on students' achievement. The results of these studies asserted that motivational style is one of the important factors affecting students' learning and performance. Hofstein and Kempa (1985) postulated that there are a number of relationships between students' motivational characteristics and their preferences for particular modes of instruction in science education. Similarly Al-Naeme (1991) looked into the influence of motivational styles on the performance of students in some creative practical problem solving tasks in chemistry, which are termed mini projects at the bench. His findings demonstrated that motivation factor was an important factor which affects students' achievement. Moreover, Al-Naeme showed that the curious groups were the best and the conscientious groups were the poorest in terms of their performance in problem solving tasks.

Rationale of This Study

One of the most important areas of physics education is electricity. Therefore, researchers have emphasized on determining students' misconceptions about DC circuits and revising those misconceptions. In the studies about misconceptions, it was stated that since electricity subject area consists of several abstract concepts, students have a number of misconceptions (Choi & Chang, 2004). Students construct misconceptions based on their pre-experiences about electricity (Duit & von Rhöneck, 1998). Thus, they come to learning environments with misconceptions about electricity phemenon (Treagust & Duit, 2008). However, misconceptions have adverse effects on students learning (Hammer, 1996). Moreover, they are more resistant to change, so it is difficult to revise with traditional learning approaches (Eryılmaz, 2002). In this view, several researchers have examined alternative learning approaches to revise students' misconceptions about electricity phenomenon. The effects of analogies (Chiu and Lin, 2005), learning cycle strategy (Ateş, 2005), simulations based on conceptual change (Başer, 2006), virtual laboratory experiments (Zacharia, 2007), computer supported inquiry learning (Başer and Durmuş, 2010) and conceptual change strategy (Taşlıdere, 2013) on students' misconceptions have already examined. However, there is no study that has aimed to determine the effects of FI/FD cognitive style and motivational styles on students' conceptual understandings about direct current circuits. Thus, the aim of this study was to investigate the effects of FI/FD cognitive styles and motivational styles on students' conceptual understandings about direct electric circuit. Based on this goal, the research questions of this study are as follows:

1. Is there a statistically significant difference between FI and FD students in terms of their conceptual understandings about direct current circuit concepts?
2. Is there statistically significant difference among students who have different motivational styles with respect to their conceptual understanding of direct current circuit concepts?

Method

Participants and Research Design

In this study a quasi-experimental research method was used (Glass & Hopkins, 1996). The participants of this study consisted of 295 (127 male, 168 female) high school students who were enrolled in 11th and 12th grade physics course in four high schools located in Düzce, Turkey. In Turkey, a national exam was administered to determine students' achievements at the end of the secondary school. According to students' performances on this exam, they managed to enter the selective high schools such as Science High School, Anatolian High School etc. All students who participated this study were enrolled at Science and Anatolian High Schools, so participants might be defined as more successful group within the high schools in Düzce. The content of physics course was determined by the Ministry of National Education and the same content is followed in all science classes in Turkey. At the beginning of a physics course, GEFT and Motivational Styles Questionnaire were administered to identify students' FD/FI cognitive styles and motivational styles (curious, conscientious, achiever and social) respectively. After the instruction regarding concepts about direct current circuits was completed, DIRECT was administered to determine students' conceptual understandings.

Instruments

Group Embedded Figures Test

In order to identify students' cognitive styles, GEFT developed by Witkin et. al. (1977) was used. This version of GEFT was devised and calibrated by El-Banna (1987) from Witkin et al's (1977) original test material. This test was translated and adapted into Turkish by Bahar (2003a). The reliability coefficient (Cronbach Alpha) was calculated as 0.812.

GEFT includes 20 complex figures. Simple shapes are located in the last page of the GEFT booklet as a specimen of the type to be found. Students were required to recognize and identify a hidden simple shape in each set of complex figures and to outline it by a pen or pencil on the lines of the complex figure. Students were supposed to complete the test in 20 minutes. At the beginning of the test, the instructions about the testing procedure were explained to them.

Motivational Styles Questionnaire

Students' motivational styles were identified by a questionnaire which was established based on Adar's (1969) and Hofstein and Kempa's (1985) work. However, the questionnaire which was used by the above mentioned researchers were modified into the form that was used in this research. This version of the questionnaire had been used in previous studies (Al-Naeme 1991; Lyall & Johnstone, 1999) and the validity and the reliability was already established. It was translated and adapted into Turkish by Bahar (2003b).

The questionnaire consisted of the statements made by female and male students regarding different aspects of teaching and learning environment about class work, laboratory work, discovery learning and social life. In the questionnaire, the statements of four individuals about different aspects of teaching and learning were presented in balloon form. The students in the sample were required to choose one of the individuals that agreed with most and to write that name down in the space at the end of each row. The following criteria is used to classify students into their motivational styles: If a student chooses four curious statements (ratio 4:0), or three curious statements and one of the others (ratio 3:1) or two curious, one achiever and one social (ratio 2:1:1), s/he is classified as curious. However, if s/he picks two curious and two of any others such as two conscientious or two achiever (ratio 2:2) or if s/he chooses four statements that all statements were different (ratio 1:1:1:1) s/he is regarded as unclassifiable. This pattern emerged as above giving the ratio 2:2 or 1:1:1:1 was considered as normal because people are thought to have a mixture of these characteristics except that they would display a bias towards one in particular.

Before starting the test, the students were informed about what they are requested to do in the test and each student was asked to sit next to each other with enough space to prevent them from interacting with others and copying from others.

Determining and Interpreting Resistive Electric Circuit Concepts Test (DIRECT)

Students' conceptual understandings of direct current circuits were assessed by

DIRECT, developed by Engelhardt and Beichner (2004). The test was used to determine students' conceptual understandings and misconceptions about DC circuits in various studies (Ateş, 2005; Başer, 2006; Başer and Durmuş, 2010). The DIRECT is a multiple choice test that probes students' common sense beliefs about concepts related to direct current circuits. This test was translated and adapted into Turkish by Ateş (2005). According to Ateş, Test's reliability coefficient was 0.74. When the data was analysed by using KR-20 reliability test, the reliability coefficient was found as 0.70 in this study.

The test consists of 29 multiple choice questions with 5 options. Students were given 30 minutes to complete the test. If a student selects the correct option, one point was given for each test item, but no point was given for students' wrong selections.

Data Analysis and Results

Students were categorized as FI, FINT and FD based on students' scores measured by GEFT. According to Bahar (2003a), students whose scores are below the score calculated as a quarter of standard deviation is subtracted from the mean score are defined as FD. On the other hand, students whose scores are above the score calculated as a quarter of standard deviation is added to the mean score are defined as FI. Students whose scores are between FI and FD are defined as FINT. In this study, the mean score and the standard deviation were found as 9.61 and 3.88 respectively. Based on Bahar's formulation, while students whose scores were below 9 were categorized as FD (f=113, 38.3%), students whose scores were above 10 were categorized as FI (f=115, 39%). Students whose scores were 9 and 10 were categorized as FINT (f=67, 22.7%). The mean scores and the standard deviations of FI, FINT and FD students are presented in Table 2.

Table 2. The Mean Scores and Standard Deviations of FI, FINT and FD Students' Conceptual Understandings Measured by DIRECT

Cognitive Style	N	$\overline{X}$	St.Dev
FD	113	10.3	3.56
FINT	67	12.95	4.64
FI	115	13.83	4.05

As can be seen at Table 2, FD, FINT and FI students' mean scores were determined 10.3±3.56, 12.95±4.64 and 13.83±4.05 respectively. One way ANOVA and Post-Hoc Tukey test were used to compare the mean scores of the groups statistically. The results of the one way ANOVA and Post Hoc-Tukey test were provided in Table 3.

Table 3. The Mean Differences among FD, FINT and FI Students' Conceptual Understandings Measured by DIRECT

	Sum of Squares	df	Mean Square	F	p	Results of Tukey Test	
						Cognitive Styles	Mean Deferences (P Values)
Between Groups	747.19	2	373.59	23.1	0.00*	FD-FINT	-2.64 (0.00*)
Within Groups	4720.88	292				FD-FI	-3.52 (0.00*)
Total	5468.08	294				FINT-FI	0.87 (0.33)

*p<0.05

As seen in Table 3, there are statistically significant differences among FI, FINT and FD students with respect to their conceptual understandings measured by DIRECT ($F_{(2, 294)}$=23.1, $p<0.05$). This result indicates that some of these groups are more successful than their counterparts in DIRECT. Post-Hoc Test was used to determine group or groups which outperformed. According to Post-Hoc Test results, it is seen that there are statistically significant differences between mean scores of FD and FINT students and FD and FI students. On the other hand, there is no statistically significant difference between the mean scores of FINT and FI students. Therefore, it might be asserted that FINT and FI students are more successful than FD students in DIRECT.

Table 4 lists the mean scores and the standard deviations of students having different motivational styles with respect to their conceptual understandings measured by DIRECT.

Table 4. The Mean Scores and Standard Deviations of Students with Different Motivational Styles with respect to their Conceptual Understandings Measured by DIRECT

Motivational Style	N	$\overline{X}$	St.Dev
Curious (Cur)	102	13.11	4.10
Conscientious (Cons)	83	12.34	4.80
Achiever (Ach)	43	13.18	4.39
Social (Soc)	67	10.35	3.25

According to Table 4, it is seen that curious, conscientious, achiever and social motivated students' mean scores were determined 13.11±4.1, 12.34±4.8, 13.18±4.39 and 10.35±3.25 respectively. One way ANOVA and Post-Hoc Tukey test were used to compare the mean scores of the groups statistically. The results of the one way ANOVA and Post-Hoc Tukey test were provided in Table 5.

Table 5. The Mean Differences among Students with Different Motivational Styles with Respect to Their Conceptual Understandings Measured by DIRECT

	Sum of Squares	df	Mean Square	F	p	Results of Tukey Test	
						Motivational Style	**Mean Deferences (P Values)**
Between Groups	354.71	3	118.23	6.729	0.00*	Soc-Cur	**-2.75 (0.00*)**
						Soc-Cons	**-1.99 (0.02*)**
Within Groups	5113.37	291	17.57			Soc-Ach	**-2.82 (0.00*)**
						Ach-Cur	0.06 (1.00)
Total	5468.08	294				Ach- Cons	0.83 (0.71)
						Cur- Con	0.76 (0.60)

*p<0.05

As seen in Table 5, there are statistically significant differences among mean scores of students with different motivational styles ($F_{(3, 294)}$= 6.729, $p<0.05$). Results of a post-hoc tukey test shows that social motivated students' mean scores are significantly lower than those of the other three groups. In addition, there are no statistically significant differences among mean scores of achiever, curious and conscientious students. This result implies that, in enhancing comprehension and achieving better performance, learning environments and assessment approaches support students whose motivational styles are achiever, curious and conscientious compared to students who are socially motivated.

Discussions

In this study, he results show that FINT and FI students are more successful than FD students with respect to their conceptual understandings about direct current circuits. Similarly, it is found that achiever, curious and conscientious motivated students are more successful thansocial oriented students. Similar findings were asserted by Karaçam (2005), Johnstone and Al-Naeme (1995), Zarotiadou and Tsaparlis (2000) and Sarantopoulos and Tsaparlis (2004).

There are two main variables that lead to these variations in conceptual understandings of groups with different cognitive styles and motivational styles. One of the main variables is structures and requirements of questions in DIRECT and the other is students' individual differences/abilities (Sencer and Eryılmaz, 2004; Karaçam, 2005). The interaction between these variables affects student's problem solving process. Students might perform if question's structure and requirement are recognized and supported by their abilities (Bennett, 1993). DIRECT consists of multiple choice questions, and majority of these questions consist of figures. One of them is provided in Figure 1. Hence, DIRECT asks students to distinguish relevant clues from irrelevant and to analysis figures. Due to these requirements' of questions in DIRECT, FI individuals who can distinguish relevant clues and can represent the parts of structure in different forms are more successful in DIRECT compared to FD individuals (Donnaruma, Cox and Beder, 1980). Similarly, since DIRECT doesn't let students to interact each other during problem solving process, the scores of social motivated students on DIRECT are lower than other groups (Bahar, 2003b). This finding shows that multiple-choice test supports achiever, curious and conscious motivated students. Similarly, Johnstone (1997) stated that the use of worksheets and multiple choice exams to assess what has just been taught are fine for conscientious and achiever motivated students.

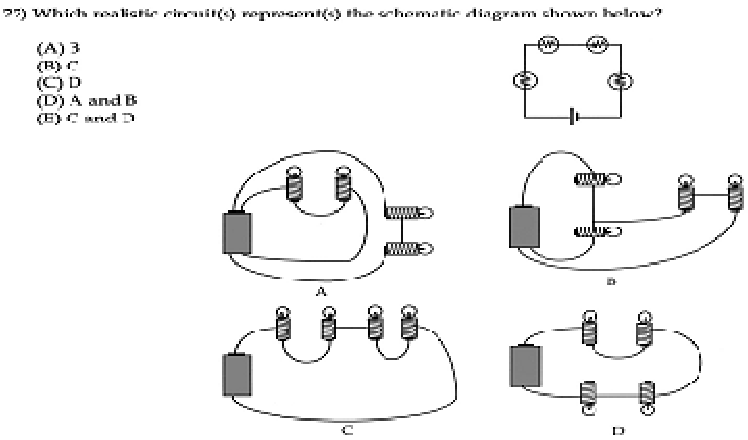

Figure 1. Sample Question in DIRECT

Learning environment is another variable that lead to these variations. Physics curriculum was revised based on constructivism in 2007 and it has been applied on all grades by 2009 (MONE, 2007). But the results of studies suggest that traditional teaching approach is still dominant in Turkey (Kapucu & Yıldırım, 2013). According to traditional approach, students are passive learners, and teacher is active. Teachers don't let students interact each other. Students learn individually. Hence, teacher gives clues them and then they recognize and memorize this factual knowledge. Since this learning environment does not consist of social interaction, social motivated students normally become unsuccessful in this situation (Bahar, 2003b). Related to FI/FD cognitive style, Lyons-Lawrence (1994) stated that whereas FI students prefer working individually, FD students prefer social learning environment. Thus, due to lack off social context in traditional learning environment, FD students who are best in social context become unsuccessful as social motivated students do (Goodenough, 1976). Besides of lack off social context in traditional learning environment, the subject of electricity consists of several abstract concepts like current, voltage, resistance, electric charge etc., and students have not opportunities to observe the movements of electric charges in circuits or to measure voltage and current by using concrete materials in traditional learning environments. Therefore, students generally construct visual images and learn those concepts intuitively. Since there is no concrete material or clues about concept in traditional learning, FI students are more successful than FD counterparts. Thus, FD students might recognize concepts provided materials and clues explicitly whereas FI students might recognize concepts via less explicit clues or materials (Goodenough, 1976).

Conclusion and Implication

The results of this study show that students' cognitive styles and motivational styles are main predictors of students' conceptual understandings about electricity, and social motivated and FD students are more unsuccessful than other groups. Differentiation among conceptual understandings of students with different cognitive and motivational styles has been solely explained based on their abilities. In addition, when the roots of these variations have been explained, task's context, format, etc. are generally ignored, which students interact with. In this view, it might be asserted that these variations among groups might originate due to traditional learning and assessment approaches that apply in learning environments in Turkey. Moreover, it might be stated that physics teachers ignore students' individual differences. However, it is stated that learning environment should be established by taking into consideration students' individual differences in Physics Curriculum (MONE, 2007). Although physics curriculum was established by taking into consideration students' individual differences, teachers have still maintained their traditional teaching process by putting away curriculum's requirements related to students' individual differences. Unless physics teachers don't obey requirements of physics curriculum, several variations among performances of students are retained. Physics teachers should not only differentiate their teaching approaches like collaborative learning, 5E etc. but also utilize alternative assessment techniques like portfolios in addition to paper pencil test in order to overcome these variations.

The previous studies that examined the effects of cognitive and motivational styles on students' conceptual understandings in physics have generally focused on force and motion subjects. This study is a first attempt to examine the effects of cognitive and motivational styles on students' conceptual understandings about electricity but this study has some limitations. We didn't include vocational high school students since their physics curriculum are far more limited, so participants are selected in Science, Anatolian and Anatolian Teacher High Schools. Students enrolled in those schools are selected by the national exam. These students have the highest scores in Düzce according to this national exam. Thus, the results of this study are related to highly successful students.

The effects of cognitive and motivational styles on students' understandings are examined in this study but these variables are not enough to explain the roots of variation in students' conceptual understandings since problem solving is a superficial process. We have to examine the effects of other individual differences like metacognitive awareness, reasoning abilities on students' conceptual understandings about electricity. Moreover, we should examine; "Does students' understandings differentiate if we use different assessment techniques?" These studies help us with determining the best effective learning and assessment approaches.

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