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Differentiated Instruction for Physics Education: An Experimental Investigation

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ABSTRACT

The purpose of this study is to determine effectiveness of using differentiated instruction in physics education. For this purpose, the study was designed according to the pretest-posttest with control group model, which is one of the quasi experimental models. The type of the application (differentiated instruction, 5E learning cycle) was determined as independent variable. The study was conducted with 58 high school students. The students were instructed in two classes as control and treatment group for three weeks by same teacher. The teacher used 5E learning cycle in control group and differentiated instruction in treatment group. Two different achievement test was used for measurement. First test was used in an attempt to demonstrate equalization of groups. Second test was used for explore the effect of the application on students' achievement. Findings revealed that there is no a significant difference between control and treatment groups before application and there is a significant difference between control and treatment groups after application. According to the results of this study, differentiated instruction can be applied on physics education.

Keywords: achievement, differentiated instruction, physics education

1 INTRODUCTION

Every person learns some information throughout his/her life. However, learning in individuals can be seen in different ways. Some people have difficulties to learn, while some others learn slowly. Some people learn by reading, while some people learn by listening to others. The main reason for this is individual differences. Individual differences is an important concept that needs special attention and be reduced by teachers in the educational process. The abilities, learning speeds, learning styles, socio-economic statuses and interests of students are different from each other. These differences are both a richness and handicap in the class. Differentiated instruction approach has been developed in order to overcome this handicap and achieve the highest level of capacity of students [1]. In differentiated instruction, teachers must first agree that different students have different needs [2]. Differentiated instruction is a teaching approach that allows content, products and process to be diversified according to the needs of students [2-5]. Differentiated instruction is a way to respond to the basic learning needs of the students. However, it is very difficult to implement differentiated instruction since it is a time and effort consuming process [6].

Teachers can differentiate three different items including the teaching process, content and product. In a teaching process, any of these can be differentiated. The content includes knowledge to be gained by the students and materials used to achieve this. Teaching process are the activities designed to understand basic knowledge and opinions of the students and let them use their skills. Product is all outcomes of the learning process [4].

Many methods may be utilized to differentiate. Stations, agendas, complex instruction, orbital studies, centers, entry points and tiered activities some of these methods. In this study, the method of agendas was used. Agenda is a list showing the tasks need to be completed by a specific student at a designated time. There are both same and different items in the agendas of all students in a classroom. Teachers create agendas for students to work around two-three weeks in general and prepare a new one when it is completed [4]. When students study on the tasks given in the agenda, teachers check them by walking among them. In this way, the teacher evaluates students' progress and gives them advices.

2 METHOD

In this study, experimental method with pretest-posttest control experiment group, which is one of the quantitative research methods, was used. The study was conducted in a public high school. Two tenth grade classes were selected as control and experiment group, respectively. The total number of students in both classes are 29. The study lasted three weeks. In this three-week period, six hours of course was provided as two hours in each week. Each course was 40 minutes. The courses were offered to the control group by using 5E learning cycle method. The experimental group received courses with differentiated instruction method. The buoyancy force included in the curriculum was taught for three weeks. There are five gains about buoyancy force in the curriculum. These gains are:

- Students explain the buoyancy force by associating it with the concept of pressure in the stagnant fluids.
- Students are provided with the description of the Archimedes principle.
- Students associate the sinking, swimming and hang events with the buoyancy force applied to the object.
- Students analyze the variables associated with buoyancy force applied to the objects by stagnant fluids.
- Students present problems about buoyancy force in their daily lives and produce solutions to overcome these problems.

2.1 Data Collection Tools

In the study, two different multiple-choice tests were used for data collection. Test questions has five choices. These tests were used as pre-test and post-test. Preliminary test consists of 18 questions. Pre-test was prepared to evaluate six different gains and three different questions were asked to measure each gain. The gains in the pre-test include concepts such as mass, volume, density and pressure. The reason for choosing these gains is the necessity of learning these concepts to learn the buoyancy force. Preliminary test was administered before the start of lessons to students in both groups. The post-test consists of 15 questions. The questions in the posttest intended to measure five gains in the buoyancy force chapter. The post-test was administrated to both groups upon completion of the chapter.

2.2 Course in the Control Group

The course was taught by 5E teaching cycle method. 5E Learning Model is based on the constructivist approach. This model enables students to concentrate on the subject. Students discover, organize and

classify the knowledge, and use and conceptualize them in the solution of new problems. This model allows students to access to information as a result of interaction with the prior experiences, classroom activities and environment [7]. 5A learning cycle comprises the following five steps:

- Engage
- Explore
- Explain
- Elaborate
- Evaluate

In the engage step, students are enabled to pay attention and concentrate on the subject and to think about the subject by creating questions in their minds. In the explore step, students make research to present their thoughts. In the explain step, concepts, process and skills become more apparent. Students explain the knowledge they have obtained about the concepts and tell their experiences. The elaborate step is related to previous three steps. Students transfer the concepts into new situations with the help of knowledge they have obtained. In the evaluate step, cognitive and affective products obtained at the end of the process are evaluated [8].

2.3 Course in the Experimental Group

In the experimental group, the courses were taught by using the agendas method, which is one of the differentiated instruction methods. Differentiation is made according to the students' prior knowledge and learning speed. The questions in the pre-test were prepared to measure the knowledge of students about buoyancy force in the previous years. In this way, the level of prior knowledge of each student was determined. Each student was given a 54-page booklet. There are 40 different tasks in this booklet. These tasks are given to learn a total of 11 gains. 6 of these gains are about pre-knowledge, while the remaining 5 gains are about buoyancy force. Tasks include four different activities as follows:

- Watching video/animation
- Reading text
- Experiments
- Question solving

Each student performed these tasks alone. They passed to the next task with approval of the teacher. This has led to differentiate according to the speed of learning.

2.4 Data Analysis

The data related to the problem of the study were analyzed using SPSS version 20. The average academic achievement scores of the students were calculated by SPSS program and then t-test was used to make comparisons between control and experimental groups and the data obtained were interpreted. The comparisons were made at the 0.05 significance level.

3 FINDINGS

Pre-test scores were used to determine whether there is a difference between control and experimental groups prior to the study. Independent group’s t-test was applied on pre-test scores. The results of independent group’s t-test and group statistics are given in Table 1.

Table 1 Comparing the Groups by Pre-Test Scores

	N	Mean	S.d.	Independent Samples t-test		
Control Group	29	16.24	2.69	t	df	Sig.
Experimental Group	29	16.20	2.42	0.51	56	0.959

Considering the data presented in Table 1, the average pre-test scores of the two groups were about 16. Since $p>0.05$ in independent groups t-test, there is no significant difference between the two groups. According to this result, it can be said that both groups are similar in term of the level of academic knowledge.

After completing the courses, the post-test was applied on both groups. The statistics of post-test scores are given in Table 2. Considering the data given in table 2, the average score of experimental group is higher. Since $p>0.05$ in independent groups t-test, there is a significant difference in favor of experimental group. Accordingly, students in the experimental group are more successful.

Table 2 Comparing the Groups by Post-Test Scores

	N	Mean	S.d.	Independent Samples t-test		
Control Group	29	9.82	2.13	t	df	Sig.
Experimental Group	29	11.17	1.62	2.69	56	0.009

4 RESULTS AND DISCUSSION

According to Table 1, there is no difference between pre-knowledge of students in both control and experimental groups before the study. After completion of the courses, as it can be seen in Table 2, students in the experimental group are more successful than the students in the control group. These results suggest that differentiated instruction method is more successful than 5E learning cycle method. Several studies in the literature support these results. Chamberlin and Powers [9] implemented differentiated instruction method in math course of university students and determined that math achievement of the students were increased. Salar and Turgut [1] suggested that the method of agendas help pre-service physics teachers to resolve their missing knowledge. Valiandes [10] conducted a quasi-experimental study on fourth grade students of a primary school and suggested that differentiated instruction improves academic achievements of these students.

Many researcher stated that designing differentiated instruction is a long and painful process [1, 2, 11]. Preparation of the agendas is a laborious and time consuming task. Although differentiation gives successful results, it is an exhausting process.

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