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THE EFFECT OF TEACHING THE SUBJECT "GRANULAR STRUCTURE OF SUBSTANCES" THROUGH A FOUR-STAGE LIFE-BASED TEACHING MODEL ON STUDENTS' ACADEMIC ACHIEVEMENT[i]

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Abstract:
The purpose of this study is to find out the effects of teaching the unite "Granular Structure of Substances" using a four-stage life-based teaching model on students' academic achievement and the retention of learning. The study employed a pretest-posttest randomized control group design. It surveyed a total of 52 6th-grade students attending a selected middle school. 24 students were included in the experimental group and 28 in the control group. The study used an "Achievement Test on the Granular Structure of Substances" consisting of 31 items as a data collection tool to measure the achievements of the main acquisitions and concepts covered in the unite "Granular Structure of Substances". Independent samples t-test and dependent samples t-test were used in in the data analysis. The research results indicated that teaching activities prepared using the four-stage life-based learning model concerning the determined subject were influential on students' academic achievement and the retention of learning. In addition, the four-stage life-based teaching model was found to be more successful in enhancing academic achievement and the retention of learning compared to the traditional approach to teaching.

Keywords: four-stage life-based teaching model, the granular structure of substances, academic achievement, retention

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1. Introduction

There are international assessment programs that survey the educational status of students around the world, such as Programme for International Student Assessment (PISA), Trends in International Mathematics and Science Study (TIMSS), and Progress in International Reading Literacy Study (PIRLS). The results obtained from these programs reveal that many countries, including Turkey, face some problems in science teaching. The major problems include students' having difficulty in using scientific knowledge and students' being less interested in science (Yılmaz, 2013). There are several reasons for the lack of students' interest in science classes including the intensity of course content, the abstract nature of topics, students' inability to associate topics with their own lives, and the lack of interdisciplinary relationships in science classes (Gilbert, 2006; Yaman, 2009). Additionally, learning cannot be achieved unless information is structured in students' mind and students' active participation in classes is ensured. Although textbooks are designed based on the constructivist approach, there are teachers who continue to use traditional teaching methods (Çelikkaya & Kuş, 2009; Çiftçi, Sünbül & Köksal, 2013; Demir, 2009).

In recent curriculum changes, constructivist learning has been brought to the forefront and added to curricula. As it has been indicated in a significant volume of research, through the use of constructivist teaching methods and techniques that facilitate students' active engagement by allowing them to filter and interpret all information to make sense in their own world, students develop such characteristics (Brooks & Brooks, 1993; Çelik, 2006; Gürol, 2002; Korsacılar & Çalışkan, 2015; Saban, 2004; Yurdakul et al., 2008). Gürol (2002) listed the basic features of the constructivist approach as learning-orientedness, content- and field-dependent information, the establishment of connections to real life (contexts), the implementation of collaborative activities, each student discovering their own truth, and the increased importance of process evaluation. In the constructivist learning approach, contexts are of great importance in making connections to reality and life. Contexts are constructed by students using examples in daily life; these contexts enable learning to take place and help students to make sense of scientific concepts (De Jong, 2008; İlhan, Doğan & Çiçek, 2015). Through contexts, students can go beyond purely abstract descriptions of concepts and build relationships between concepts and everyday life (İlhan, Yılmaz, Kutu, Sözbilir & Yıldırım, 2015). Research on constructivist learning also noted that it should not be away from the context, that is, the life (Jonassen, 1991 as cited in Parlak-Yılmaz 2003). Similarly, the main theme of life-based teaching approach is to present concepts in relation to everyday life and to ensure that students need information and knowledge (İlhan, 2011). Many countries including Turkey today use a life-based teaching approach in curriculum development activities (Bennett & Lubben, 2006). Following the success of such curricula developed and implemented in different countries, the life-based teaching approach has become more and more accepted. İlhan, Doğan and Çiçek (2015) highlighted that some science curricula (biology, physics and chemistry) at elementary school, high school and university levels in many countries such as the USA, Germany, the Netherlands, and the UK are designed in accordance with life-based teaching approach.

Korsacılar and Çalışkan (2015) define life-based teaching approach as a teaching method that aims to increase the interest and willingness of students in science subjects, and to enable them to learn new information building upon their own experiences. In the life-based teaching approach for teaching scientific concepts

In the life-based teaching approach, contexts are used as starting point in classes to teach scientific concepts (Bennett, Lubben & Hogarth, 2007). Several studies on life-based teaching (Bennett, Lubben & Hogarth, 2007; Demircioğlu, Dinç & Çalık, 2013; İlhan, 2010; Ingram, 2003) reported positive effects on students' academic achievement, attitude, motivation, and science/scientific literacy. The literature includes various studies reporting the combination of life-based teaching with 5E model-based REACT strategy, ARCS model and four-stage model of learning (Çiğdemoğlu, 2012; Demircioğlu, Dinç & Çalık, 2013; Ingram, 2003; Kutu & Sözbilir, 2011; Nentwig, Demuth, Parchmann, Gräsel & Ralle, 2007; Tekbıyık, 2010; Ültay & Çalık, 2011). In an aspect different from these studies, the present study attempts to combine the life-based teaching approach and the four-stage model for teaching the "Granular Structure of Substances" among secondary school chemistry subjects and accordingly to design teaching activities. Below the study presents information on the steps of the four-stage model that is included in the scope of this study and most commonly used in life-based teaching practices.

A. Introduction stage: The class starts with a story or visual presentation that represents the connection of daily life. Thus, students find themselves in a story, a play or an event prepared by the teacher. This story or play is related to the real life.
B. Curiosity and planning stage: Students are encouraged to ask questions. Students ask questions and try to find out what they know, that is, old information, and what they understand from the story. Discussions take place among students; the teacher serves as a guide in this process.
C. Development stage: Concepts in the story are formulated by students through subject-related activities. Students try to make sense of discussions held at the previous stage. This process can include experiments, modelling, solving numerical problems and doing activities with various worksheets.
D. Stage of establishing connections: Activities and concepts in the introductory stage are linked to those in the development stage. At this stage, the teacher makes non-understood or misunderstood concepts understandable. Students are asked to verbally present or report what they have learned.

1.1 Research Purpose

The purpose of this research is to reveal the effect of teaching the subject "Granular Structure of Substances" through the four-stage life-based teaching model on students' academic achievement and the retention of learning. To this end, answers to the following research problems were sought:

1. Is there a significant difference in the academic achievement of the students in the experimental and control groups in terms of teaching the subject "Granular Structure of Substances" through the four-stage life-based teaching model?
2. Does it have an effect on the retention of what is learned by the students in the experimental and control groups when the subject "Granular Structure of Substances" is taught using the four-stage life-based teaching model?

2. Material and Methods

The following part presents the research design, the research sample, data collection tools, data collection, and data analysis to reveal the effect of teaching the subject "Granular Structure of Substances" through the four-stage life-based teaching model on students' academic achievement and the retention of what they have learned.

2.1 Research Design and Sample

To find out the effect of the four-stage life-based teaching model on students' academic achievement and the retention of learning, the study employed a pretest-posttest control group quasi experimental design.

Considering the sampling of the students (experiment and control), the study was conducted in the class sections already designated in the school However, the study employed a random assignment method for the selection of which section was treated as the experimental group or the control group. The research was carried out with an experimental group and a control group.

The research sample consisted of 52 6th-grade students attending Şehit Kurmay Binbaşı Ufuk Bülent Yavuz Middle School selected through convenience sampling in the city center of Bursa. The experimental group consisted of 24 students (14 girls, 10 boys) and the control group 28 students (11 girls, 17 boys). Table 1 shows the distribution of students in the experimental and control groups by gender.

Table 1: Distribution of Students in the Experimental and Control Groups by Gender

	Girls		**Boys**		**Total**	
Group	f	%	f	%	f	%
Experimental	14	26.92	10	19.23	24	46.15
Control	11	21.15	17	32.69	28	53.84
Total	25	48.07	27	51.92	52	100.00

2.2 Data Collection Tools

The data was collected using an "Achievement Test on the Granular Structure of Substances" developed by the researchers in accordance with the acquisitions covered in the relevant unite of the 6th-grade Science Education Curriculum of 2013 (MEB, 2013). The final test tested for validity and reliability is a 31-question multiple-choice test with 4 choices for each question. For scoring the test, "1" point was given for each correct answer and "0" point for each false answer.

At the pre-implementation stage of the test, necessary data were obtained for the development phase of the test. For this purpose, the first version of the "Achievement Test on the Granular Structure of Substances" consisting of 38 questions was applied to a total of 335 6th-grade students. In the analysis of the data obtained from the pilot test applications, item discrimination and difficulty were separately calculated for each test item. Considering the discrimination coefficients of the test items, there were 3 with a discrimination coefficient less than 0.30 (items 18, 32, and 37). Considering the difficulty of the remaining 35 items, items 2 and 13 were excluded from the test because of being quite easy (within the range of 0.65 and 0.79), item 13 was excluded because of being very easy (0.8 and greater), and item 28 was excluded due to the large number of questions. Thus, the final test consisting of 31 items was formed after 7 items in total were excluded from the first version. Additionally, Cronbach's alpha coefficient of the test was computed; it was found 0.895 for the pilot application and 0.892 for the final application. A reliability coefficient of 0.70 or higher for a measurement instrument is generally considered sufficient for the reliability of measurement results (Büyüköztürk, 2005). The Achievement Test on the Granular Structure of Substances was used as a pre-test, post-test and retention test in this research.

2.3 Data Collection

The applications within the scope of this research were carried out in science classes in the spring term of the 2015-2016 academic year. The application lasted for a total of four weeks (16 lesson hours). A pre-test was applied to both groups in the first class prior to the experimental application. The measurement tool Achievement Test on the Granular Structure of Substances was applied to the experimental and control groups as a pre-test and reapplied to both groups as a post-test at the end of the experimental application. During the application process, the experimental group was taught using the four-stage life-based model, while the practices and activities included in the current curriculum were carried out in the control group. Four weeks after the applications were completed; the Achievement Test on the Granular Structure of Substances was reapplied to both groups as a retention test in a determined class.

2.4 Data Analysis

The scores that the participating students achieved in the Achievement Test on the Granular Structure of Substances composed the research data. The normal distribution and homogeneity of the data to be compared was tested to ensure that this achievement test yielded reliable results. The Shapiro-Wilk test was interpreted because the number of data in each group (the experimental and control groups) was less than 29. As seen in Table 2, the pre-test (0.049>0.01), post-test (0.231>0.01) and retention test (0.200>0.01) scores of 24 students in the experimental group showed normal distribution. Similarly, the pre-test (0.019>0.01), post-test (0.376>0.01) and retention test (0.019>0.01) scores of 28 students in the control group also showed normal distribution.

In the analysis of the data, dependent samples t-test was performed to find out whether academic achievement differs among the students attending the class delivered based on the four-stage life-based teaching approach and among those involved in the control group. Accordingly, students' pre-test and post-test scores and their post-test and retention test scores were compared. Additionally, independent samples t-test was also performed to find out whether there is a difference between pre-test and post-test scores and between post-test and retention test scores of the experimental group and control group. All tests were performed at a significance level of 0.01.

Table 2: Normal Distribution Results of the Pre-test, Post-test and Retention Test Scores of the Experimental and Control Groups

Tests	Groups	Shapiro-Wilk	
		df	p
Pre-test	Experimental	24	.049
	Control	28	.019
Post-test	Experimental	24	.231
	Control	28	.376
Retention test	Experimental	24	.200
	Control	28	.019

p>.01

The following part presents the results of the data analysis concerning two research problems.

First, an answer was sought to the first research problem "*Is there a significant difference in the academic achievement of the students in the experimental and control groups in terms of teaching the subject Granular Structure of Substances through the four-stage life-based teaching model?*". The relevant results are given below.

Table 3: Independent Samples T-test Results of the Pre-test and Post-test Scores of the Experimental and Control Groups

Tests	Groups	N	Mean	S	t	p
Pre-test	Experimental	24	12.67	4.219	1.808	0.077
	Control	28	10.46	4.509		
Post-test	Experimental	24	18.50	4.065	5.142	0.000**
	Control	28	12.07	4.830		

**p<.01

As seen in Table 3, the comparison of the pre-test scores of the experimental and control groups yielded no significant difference in their scores in the achievement test (t=1.808; p>.01). However, the pre-test mean scores of the groups were very close to each other. This indicates that the groups were equal before the experimental application. The results of independent samples t-test yielded a significant difference in favor of the experimental group, considering the post-achievement test scores of the students in the experimental and control groups (t=0.00; p<.01). The pre-test mean scores of both groups were close ($Mean_{experimental}$=12.67; $Mean_{control}$=10.46). Thus, teaching the subject Granular Structure of Substances through the four-stage life-based teaching model was effective in enhancing students' academic achievement. Considering the post-test mean scores, the experimental group had much higher post-test mean scores ($Mean_{experimental}$=18.50) compared to the control group ($Mean_{control}$=12.07).

Table 4: Dependent Samples T-test Results of the Pre-test and Post-test Scores of the Experimental and Control Groups

Groups	Tests	N	Mean	S	t	p
Experimental	Pre-test	24	12.67	4.219	-9.524	0.000**
	Post-test	24	18.50	4.065		
Control	Pre-test	28	10.46	4.509	-2.592	0.015
	Post-test	28	12.07	4.830		

**p<.01

As seen in Table 4, based on the results of dependent samples t-test, there was no statistically significant difference between the pre-test and post-test mean scores of the control group (t=-2.592, p>.01). The difference in the control group's mean scores before and after the application was found ($Mean_{post-test}$ - $Mean_{pre-test}$=1.61). On the other hand, there was a statistically significant difference between the pre-test and post-test mean scores of the experimental group (t=-9.524, p<.01) and this difference was in favor of the post-test. Additionally, considering the difference between the pre-test and post-test mean scores of the experimental group ($Mean_{post-test}$ - $Mean_{pre-test}$=5.83), the difference was greater compared to the control group.

The following part includes the results of the second research problem "*Does it have an effect on the retention of what is learned by the students in the experimental and control groups when the subject Granular Structure of Substances is taught using the four-stage life-based teaching model?*".

Table 5: Independent Samples T-Test Results of the Retention Test Scores of the Experimental and Control Groups

Test	Group	N	Mean	S	t	p
Retention	Experimental	24	19,21	4.943	5.733	0.000**
	Control	28	11.04	5.274		

**p<.01

As seen Table 5, according to the results of independent samples t-test, there was a significant difference in favor of the experimental group, considering the retention test scores of the experimental and control groups in the achievement test (p<.05). This indicates that the experimental application produced a greater effect on the retention of knowledge in the experimental group. This result is also evidenced by the much higher retention test mean scores of the experimental group ($Mean_{experimental}$ =19.21) compared to those of the control group ($Mean_{control}$ =11.04).

Dependent samples t-test was performed to find out the difference between the post-test and retention test mean scores of the experimental group and the control group (Table 6). According to the analysis results, there was an increase or decrease in the post-test and retention test mean scores of both the experimental and control groups; however, this increase and decrease were not significant.

Table 6: Dependent Samples T-test Results of the Retention Test and Post-test Scores of the Experimental and Control Groups

Group	Tests	N	Mean	S	t	p
Experimental	Post-test	24	18.50	4.065	-0.893	0.381
	Retention test	24	19.21	4.943		
Control	Post-test	28	12.07	4.823	1.669	0.107
	Retention test	28	11.04	5.274		

$p>.01$

Whether there is a significant difference among the tests applied at the outset and at the end of the experimental application was also investigated and additional analyzes were also conducted as shown in Table 7. Accordingly, dependent samples t-test was performed to find out the difference between the pre-test and post-test of the experimental and control groups. According to the analysis results, the difference between the aforesaid tests was significant in the experimental group but not in the control group. This result indicates that teaching the subject Granular Structure of Substances through the four-stage life-based teaching model has an effect on the retention of what students learned.

Table 7: Dependent Samples T-Test Results of the Retention Test and Pre-Test Scores of the Experimental and Control Groups

Group	Tests	N	Mean	S	t	p
Experimental	Pre-test	24	12.67	4.219	-6.173	0.000**
	Retention test	24	19.21	4.943		
Control	Pre-test	28	10.46	4.509	-0.743	0.464
	Retention test	28	11.04	5.274		

**$p<.01$

Figure 1 below evidences the result that the four-stage life-based teaching model is effective in promoting the retention of knowledge. In the comparison of the pre-test, post-test and retention test mean scores between the experimental and control groups, the mean score of the experimental group in three tests ($Mean_{experimental}$=16.79) was higher than that of the control group ($Mean_{control}$=11.19). Thus, it seems that teaching the subject Granular Structure of Substances through the four-stage life-based teaching model applied to the experimental group was more effective in enhancing students' achievement.

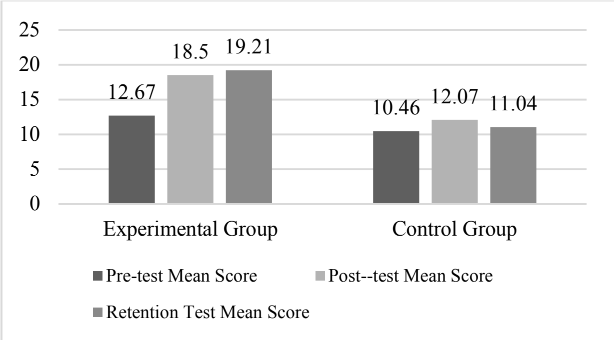

Figure 1: Comparison of Pre-test, Post-test and Retention Test Mean Scores of the Experimental and Control Groups

3. Discussion and Conclusion

The present study combined the life-based teaching approach with the four-stage model and accordingly tried to design teaching activities concerning the subject "Granular Structure of Substances". It also attempted to determine the effect of the designed activities on students' achievement and retention of knowledge. The data obtained from measurement instruments were interpreted through dependent and independent samples t-test analysis. First, the study analyzed the pre-test scores in the achievement test applied to the 6^{th}-graders and confirmed that there was no significant difference between the groups. Accordingly, the inclusion of the experimental and control groups in the study was deemed appropriate. Following the experimental application, the study compared the post-test scores of the experimental and control groups in the achievement test and found a significant difference in favor of the experimental group. Additionally, the study also compared the pre-test and post-test scores in the achievement test for each group and found no statistically significant difference between the control group's mean scores but a statistically significant difference between the experimental group's mean scores. Considering all these results, the consolidation of science course involving many abstract concepts with a four-stage life-based teaching model is more effective in enhancing students' achievement. Elmas (2012) reported that the effects of the teaching activities developed based on the life-based teaching approach for the chemistry subject "Cleaning Agents" were in favor of the experimental group. İlhan (2010) also found that life-based teaching approach is effective in promoting student achievement and motivation. The data obtained in many studies conducted with different age groups are consistent with the result that life-based teaching enhances students' academic achievement (Çam, 2008; Çiğdemoğlu, 2012; Elmas, 2012; Ekinci, 2010; İlhan, 2010; Kara, 2016; Özay-Köse & Tosun, 2011; Rioseco, 1995; Sari, 2010; Ulusoy, 2013; Ünal, 2008; Yiğit, 2015).

The research results also indicated that the difference between the post-test and retention test was significant in the experimental group but not in the control group. Accordingly, teaching the subject Granular Structure of Substances through the four-stage life-based teaching model has an effect on the retention of what students learned. It also suggests that knowledge is more persistent in this approach compared to traditional approach. This may stem from contexts chosen from everyday life to be used in the teaching of the subject. The materials prepared in accordance with the four-stage life-based model facilitated students' active participation in the classes and helped them to be aware of the relationship between the subject and everyday life. This situation is supported by the positive results obtained in favor of the experimental group in all the tests. The literature also includes studies reporting that the life-based teaching approach has a positive effect on the retention of what students learn (Korsacılar & Çalışkan, 2015).

4. Suggestions

Based on the research results, the following suggestion can be offered:

- The four-stage life-based teaching model can be applied to different and larger samples, and to different learning domains and science subjects.
- Further research can investigate the effects of the four-stage life-based teaching model on various variables such as attitude, self-efficacy, conceptual learning.

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