USAGE OF UNIVERSAL DESIGN FOR LEARNING IN MATHEMATIC COURSE

Abstract: The aim of this study is to investigate the effect of Universal Design for Learning on students' academic achievement and attitudes towards mathematics course, and to reveal the opinions of the students about Universal Design for Learning. In this study, the concurrent embedded strategy was used. The participants consisted of 33 primary school students from two different 4th grade classes at a primary school. In the quantitative part of the study, non-equivalent control groups design was utilized. Data were collected through an academic achievement test and an attitude scale. The findings indicated that Universal Design for Learning had a large effect on academic achievement and attitudes towards mathematics course. In the qualitative part of the study, case study was used and data were collected through a focus group interview. The students participating in the interview were identified with a maximum variation sampling method. The students stated that Universal Design for Learning improved their attention, interest, cooperation, and self-regulation skills. They also stated that Universal Design for Learning supported their retention of knowledge, multiple representations of knowledge, and active participation to lesson. As a result, Universal Design for Learning is thought to be one of the effective methods in mathematic courses and its use is recommended. This study was derived from the master's thesis named "The Effect of Universal Design for Learning on Students Academic Achievement and Attitude towards Mathematic Course".

Keywords: Academic achievement, attitude, primary school students, student opinions, universal design for learning

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INTRODUCTION

Universal Design (UD) approach was applied in architecture and products design (Rose, 2000). UD became philosophical basis in the design of many educational products and environments (Burgstahler, 2007). The adaptation of UD principles to education had yielded good results only in educational technologies (Eagleton, 2008), as it was not supported by brain research. (Hitchcock & Stahl, 2003). So, The Center for Applied Special Technology (CAST) developed Universal Design for Learning (UDL) by supporting brain researches.

Modern neuroscience sees the brain as a complex link of interconnected networks, rather than as a collection of discrete structures with specific functions. Learning is also seen as a change in connections within and among these networks (Meyer, Rose & Gordon, 2014). UDL focuses on three brain networks: recognition networks, strategic networks, and affective networks. Three basic principles were developed based on these networks. The principles of UDL are "to provide multiple means of representation, to provide multiple means of action and expression, to provide multiple means of engagement" (CAST, 2018). These principles taken into account the varied students, including students in the margins. They were used to guide the design of learning tools, methods and environments (Meyer et al., 2014).

The recognition networks help us understand and interpret the patterns of sound, light, taste, smell, and touch. These networks enable us to recognize more complex patterns such as an author's style and differences as well as abstract insights, sounds, faces, letters, words, and justice. The principle of providing multiple means of representation bring recognition networks together. These networks allow us to interpret and define the stimuli that reach us through our sensory organs. It helps us to find not only simple and complex but also abstract and concrete meanings. As a result, our brain and body interact with sensory inputs that affect our learning (Rose & Meyer, 2002).
Students differ in the way they perceive and, then understand the information presented to them. For example, students with sensory disabilities (such as students with hearing and visually impaired), learning disabilities (such as dyslexia), language or cultural etc. differences need different ways to enable them to reach content. So, it is necessary to use multiple representation tools (CAST, 2018).

The strategic networks control complex strategic capacities which determine goals, planning appropriate strategies, and self-monitoring. The principle of providing multiple means of action and expression brings together strategic networks (Rose & Meyer, 2002). This principle is related to students' goal setting, planning, strategy formation, use, and organization of information and resources. It provides options to monitor students' own progress in these areas (Nelson, 2014). Students reflect what they have learned in a learning environment and can express what they know in different ways. So, the multiple means of action and expression must be provided to indicate their own learning.

Affective networks impart emotional significance to objects, actions and, patterns. The principle of providing multiple means of engagement brings together affective networks (Rose, 2001). They involve to develop interest, motivation and, more importantly, strong self-regulation capabilities in the learners. Students have in their ways of being engaged or motivated to learn. (Meyer et al., 2014). In fact, there is no optimal means of engagement for all students in all areas. It is essential to offer multiple options for engagement (CAST, 2018).

IMPORTANCE OF THE RESEARCH

"Nobody is the same as someone else." approach has been adopted in the mathematics curriculum (Ministry of National Education of Turkey [MEB], 2018). This approach overlaps with the UDL approach. According to UDL, individual differences are natural in the learning environment. It is necessary to provide fair and

equal opportunities to students with different abilities, backgrounds and motivations. In addition, UDL aims for all students to become an expert learner. For these reasons, there is no a

single representation, a single action and expression, a single motivation and a single

assessment tool in UDL. UDL is a teaching model that requires planning the course to cover all student variability, including students with the margins (Meyer et al., 2014). Therefore, UDL could be effective in ensuring students have the desired skills. In addition, it was thought that UDL could be appropriate for students to achieve the goals, objectives and skills in the Mathematics curriculum.

PURPOSE OF THE RESEARCH

The aim of this study is to investigate the effect of UDL on students' academic achievement and attitudes towards mathematics course, and to reveal the opinions of the students about UDL.

PROBLEMS

For this purpose, answered to the following sub-problems were sought:

1. Does UDL have an effect on students' academic achievement in mathematics course?
2. Does UDL have an effect on students' attitudes towards mathematics?
3. What are the student opinions about UDL applied in mathematics course?

METHOD

In this study, concurrent embedded strategy from mixed methods was used as research design. A mixed method is defined as a type of research in which qualitative and quantitative methods are used together (Creswell, 2012). In the quantitative part of the study, non-equivalent control groups design was utilized. In this design, students are not randomly assigned to a group. Instead, one of the equivalent groups is assigned as an experiment and the other as a control group (Gay & Airasian, 2000). In the qualitative part of the study, case study was used. The case study model is defined as a current phenomenon that runs within real-life boundaries; that the boundaries between the phenomenon and related content are not clearly separated; used in cases where more than one evidence or data source is available (Creswell, 2012). The achievement test and attitude scale were applied as pre-test to the experimental and control groups before the treatment. During the study, UDL was applied in the experimental group and the teaching based on curriculum was applied in the control group. After the treatment, the achievement test and attitude scale were applied as the post-test to both groups. In addition, the experimental group students were interviewed with respect to the UDL applications during the study.

PARTICIPANTS

The participants consisted of 33 students studying in two different 4th classes. There were 16 students (12 girls and 4 boys) in experimental group and 17 students (6 girls and 11 boys) in control group. This indicates that the distribution of female and male students is not equal in both groups. So, factorial covariance analysis was performed to determine whether gender factor has an impact on the dependent variable. At the end of the analysis, it was found that gender was not an effective factor on students' achievement ($F_{(1,32)}$= 0.104; $p>0.05$) and attitudes towards the course ($F_{(1,32)}$= 0.010; $p>0.05$).

In order to examine whether the groups were equal or not before the study, independent samples t-test was applied in the comparison of the pre-test mean scores of the achievement test and attitude scale was applied to the students. It was observed that there was no significant difference between the experimental group (M=11.00; SD=3.70) and the control group (M=9.52; SD=2.42) in terms of achievement pre-test mean scores ($t_{(31)}$=1.35; $p>0.05$). Also, it was observed that there was no significant difference between the experimental group (M= 4.22; SD= 0.51) and the control group (M=4.00; SD=0.61) in terms of attitude scale pre-test mean scores ($t_{(31)}$=1.12; $p>0.05$). These analysis results indicate that the pre-test mean scores of the achievement test and attitude scale of the experimental and control groups were equivalent before the study.

INSTRUMENTS

ACADEMIC ACHIEVEMENT TEST

There are 26 objectives from the Primary School 4th Grade Curriculum. Two questions were prepared to measure each of the 26 goals and a trial form consisting of 52 questions was developed. The trial form was applied to a total of 234 fifth graders. In order to select final test

questions, item difficulty and distinguishing index of the test was examined. Considering the content validity of the questions, it was tried to choose questions with medium difficulty (pj=0.50) and high level of distinctiveness (rjx>0.30). The final test consisted of 26 questions. Mean of item difficulty index of test items was 0. 508, mean of item distinguishing index was 0.617. Cronbach Alpha internal consistency coefficient was calculated as 0.87.

MATHEMATICS ATTITUDE SCALE

The scale consisting of 18 items was developed by Aladağ (2005). The scale items used in the study consist of nine positive and nine negative expressions. The scale was prepared in form of 5-point Likert type. The Cronbach Alpha reliability of the scale was calculated as 0.82. The reliability of the scale in this study was found to be 0.84.

INTERVIEW

Interview questions were prepared to take the opinions of students about UDL. The participants were selected by maximum variation sampling. The students to be interviewed were determined by taking into consideration the successes in the mathematics course. Two high achieving, two medium achieving, and low achieving students were selected. In addition, students who can express themselves well were carefully selected. The interview was conducted at the same time as all the students with focus group discussion. The reliability of the interview was coded by both researchers and the number of codes in consensus was divided by the total number of codes. The reliability coefficient was found to be 0.87.

PROCESS

An 18-week study plan was prepared according to the UDL to be applied in the experimental group.

The lesson plan, which was prepared in such a way as to include each principle of the UDL, was finalized by taking an expert opinion. According to the study plan, pre-tests were applied to the experimental and control groups during the first week. In the following weeks, teaching activities were carried out in accordance with the lesson plan. At the end of the study, post-tests were applied to both groups and six students from the experimental group were interviewed.

DATA ANALYSIS

The paired samples t-test was used to compare the pre-test and post-test mean scores of the experimental and control groups. Factorial covariance analysis was performed to determine whether there was a significant difference between the post-test scores. Eta square value (η^2) is interpreted as no effect up to 0.01, as small effect between 0.01 – 0.06, medium effect between 0.06 – 0.14 and have a large effect on 0.14 (Green, Salkind & Akey, 2000). Descriptive analysis was utilized to analyze the data obtained from the interview. The data obtained for the purpose of examining the contribution of UDL to the teaching process and learning outcomes are accumulated under attention, interest, multiple representation, cooperation, retention, active participation, self-regulation codes.

RESULTS

1. Results Related to the Students' Academic Achievement

Firstly, the experimental and control group students' achievement test pre-test mean scores and post-test mean scores were compared with paired samples t-test. The data obtained are presented in Table 1.

Table 1. Paired Samples t-test Results

		Experimental Group							Control Group						
Test		N	M	SD	df	t	p	η^2	N	M	SD	df	t	p	η^2
Ach. Test	Pre-test	16	11.00	3.70	15	-9.93*	0.000	0.87	17	9.52	2.42	16	-4.16*	0.001	0.52

	Post-test	16	20.37	5.13					17	13.58	3.16				

*p<0.05

According to Table 1., there was a significant difference between the experimental group students' academic achievement pre-test mean scores (M= 11.00; SD= 3.70) and post-test mean scores (M= 20.37; SD= 5.13) in favor of the post-test ($t_{(15)}$; 9.93; p< 0.05). The eta square value (η^2) of this difference was calculated as 0.87. This value indicated that UDL had a large effect on students' mathematics achievement. This value also implied that UDL predicted 87% of the students' mathematics achievement. Similarly, there were significant differences between the pre-test mean scores (M= 9.52; SD= 2.42) and the post-test mean scores (M=13.58; SD= 3.16) of the control group students' in favor of the post-test ($t_{(16)}$ =4.16; p<0.05). The eta square value (η^2) of this difference was calculated as 0.52. Accordingly, these values indicated that teaching based on curriculum had a large effect on students' mathematics achievement. This value implied that teaching based on curriculum predicted 52% of the students' mathematics achievement.

The post-test means for the achievement test of both groups were compared with covariance analysis. The pre-test scores were designated as covariance. The data obtained are presented in Table 2.

Table 2. ANCOVA Results

Post-test	Source	Sum of Square	df	F	p	η^2
Ach. Test	Pre-Test	105.614	1	7.056	0.007	-
	Group	260.903	1	17.431*	0.000	0.38
	Gender	13.571	1	0.907	0.349	-
	Gender * Group	1.553	1	0.104	0.750	-
	Error	419.103	28	-	-	-
	Corrected total	935.515	32	-	-	-

*p<0.05

Table 2 depicted that there was a significant difference in favor of the experimental group between the post-test mean scores of the experimental and control group students when academic achievement pre-test mean scores ($F_{(1,32)}$= 17.431; p< 0.05) were held constant. Accordingly, it indicated that UDL was more effective in increasing students' mathematics achievement than teaching based on the curriculum. The eta square value (η^2) of this difference was calculated as 0.38. This value signified a large effect. This value also depicted that UDL had a 38% larger effect on students' achievement in mathematics course than teaching based on the curriculum.

2. Results Related to the Students' Attitudes

The experimental and control group students' attitude scale pre-test mean scores and post-test mean scores were compared with paired samples t-test. The data obtained are presented in Table 3.

Table 3. Paired Samples t-test Results

		Experimental Group							Control Group						
Test		N	M	SD	df	t	p	η^2	N	M	SD	df	t	p	η^2
Attitude Scale	Pre-test	16	4.26	0.43	15	-3.45*	0.04	0.44	17	4.00	0.61	16	-0.46	0.64	-

	Post-test	16	4.55	0.29					17	4.07	0.74				

*p<0.05

With regards to attitude scores, Table 3 depicted that there was a significant difference between the pre-test mean scores (M=4.26; SD= 0.43) and the post-test mean scores (M= 4.55; SD= 0.29) of the experimental group students' in favor of post-test ($t_{(15)} = 3.45$; $p < 0.05$). The eta square value (η^2) of this difference was calculated as 0.44. This result demonstrated that UDL had a large effect on students' attitudes towards mathematics course. This value also indicated that UDL predicted 44% of the students' attitudes towards mathematics course. But, there was no significant difference ($t_{(16)} = 0.46$; $p>0.05$) between the pre-test mean scores (M=4.00; SD= 0.61) and the post-test mean scores (M= 4.07; SD= 0.74) of the control group students. Accordingly, it was understood that teaching based on curriculum was not effective in increasing students' attitudes towards mathematics course.

The post-test means for the attitude scale of both groups were compared with covariance analysis. The pre-test scores were designated as covariance. The data obtained are presented in Table 4.

Table 4. ANCOVA Results

Post-	Source	Sum of Square	df	F	p	η^2
Attitude Scale	Pre-Test	3.579	1	14.582	0.001	-
	Group	0.664	1	2.707	0.111	-
	Gender	0.19	1	0.078	0.783	-
	Gender * Group	0.002	1	0.010	0.921	-
	Error	6.872	28	-	-	-
	Corrected total	12.458	32	-	-	-

Table 4 depicted that there were no significant differences in favor of the experimental group between the post-test mean scores of the experimental and control group students when attitude scale pre-test mean scores ($F_{(1,32)}=2.707$; $p>0.05$) were held constant. Accordingly, it revealed that UDL did not have a significant effect on students' attitudes towards mathematics course compared to teaching based on the curriculum.

Findings Related to the Student Opinions about UDL

3. Results Related to the View of Students' about UDL

In this part, the student opinions on UDL had been presented. The data obtained after the interview was analyzed by descriptive analysis. Codes obtained were presented respectively.

ATTENTION

In order for any subject to be learned, attention must be paid first. Although there are many stimuli in the environment, the attended stimulus is perceived and learned (Woolfolk, 2001).

> S4: *... I wasn't paying attention. When you teach something, and I go to the front row, it caught my attention and I could see well.*

As a result of the change in the place in the classroom, student 4 had an important role in perception, and it affected the level of attention positively. Accordingly, it showed that the regulation of the environment according to the needs of the individual might positively increase the attention in the course.

> S1*: ... I was constantly distracted beforehand. I'm not distracted anymore.*

Unentertaining lesson distracted students' attentions and directed them to various stimuli. Therefore, lessons needed to be planned an interesting way.

INTEREST

Another important factor in learning is interest. Students need to be interested in the subject to be able to learn. Although the interest of the students

depends on many factors, the course should be planned in accordance with the level of the students and remarkably.

> S4: ... *I didn't like math when you were new, I didn't care, I didn't pay attention.... I can solve problems now.*
> S3: ... *I didn't care, I wasn't doing anything. ... My sister writes on paper and I solve it at home. ... I can understand better.*
> S2: ... *I didn't like math when you were away. I started to like you when you came. ... I didn't want to solve problems when I went home before. I want my sister to write a problem now. She writes and I solve it.*

The students' opinions indicated that they overcame their missing learning and skills with the studies that in accordance with levels and attracted the interest of the students. According to the representation principle of the UDL, it is important to activate and supply background knowledge in providing options for comprehension. It could be said that learning deficiencies of students were solved and background knowledge was tried to be formed and so their interest increased in the class and their interest continued outside the school.

> S2: ... *I was looking at the books before, not listening. It was a lot of fun telling you. ... I was learning everything.*

The statement of student 2 revealed that the interesting way of explaining the subject increased the interest of students and facilitated learning. Thus, it was effective in providing the students with the opportunity to perceive the audio-visual alternatives and to enable them to express the information, which aligned with the UDL requirement.

MULTIPLE REPRESENTATION

To learn any subject, students need representation tools and various activities appropriate to the level of the students who aim to show their learning objectives and what they have learned. Students have the opportunity to choose the appropriate tools and activities. Exposing students to various activities in the learning environment also serves the purpose of creating expert learner parallel to the purpose of the UDL.

> S2: ... *You didn't write, you put papers on the board.*
> S1: ... *You were never writing. ... You were making a big paper, hanging on the board. ...*

Based on statements of the students, it assumed that there were studies about the principle of representation of UDL. Here, it was aimed to activate or supply background knowledge and to emphasize the critical features of the subject and the relations between the subjects in order to provide the students with the options for comprehension the subject. When students focused on writing, they could overlook critical features and key concepts. This might cause problems in comprehension of the subject. It indicated that multiple representations increased transfer of learning.

> S2: ... *We were making activities.*
> S6: ... *We were doing group work.*

The aim of the above-mentioned studies was to provide learning by providing multiple means of action and expression from UDL principles. Through the diversification of activities, students' skills and interests could be addressed and could be possible to learn the subject. It was difficult to address all students and taught the subject with a single activity. In the activities carried out in the classroom, multiple representations were ensured by paying attention to individual differences.

> S4: ... *I loved the shortcut of the division. Zeros go, division ends.*
> Students: ... *Multiply, subtract, down, do it again (showing with hand gestures).*

According to these expressions, it was understood that the students were offered options to express their taught subject. For this purpose, rhymes and hand gestures were used. Student 4's said rhymes about the shortcut of the division and all students' showed each stage of the division process by hand gestures could also provide that there were multiple representations in providing options for representation.

S3: ... *We were doing activities on the smart board.*

Student 3 referred to the use of technology. The aim was to provide learning by providing multiple representations from the principles of the UDL. It had also been applied to the use of technology in other UDL principles such as providing multiple means of action and expression, providing multiple means of engagement. Thus, technology was used as a tool to provide multiple representations.

S5: ... *You did something like a crocodile, played with them.*
S6: ... *You gave us something like a hat. ... we found the shape that disrupts the pattern.*

Students 5 and 6, mentioned that the games used to teach the subject. It was aimed to provide multiple means of representation by using games as well as activities in the courses.

COOPERATION

Sometimes students may be inadequate in expressing and indicating they have difficulty in learning. At this stage, peer teaching can help these students. Organizing collaborative activities helps students learn from each other and express themselves more easily. They also develop their skills in working together and helping.

S1: ... *Our friends were attending with us. ... They weren't helping me. ... We didn't do it all together in the group works, but then we started to do it.*
S2: ... *We did everything we learned with our friends.*

Student 1's statements indicated that they did not know how they did group work. But then it described that they began to learn how to work together and develop these skills. This situation was understood from the statements of student 1 and 2.

S3: ... *I was asking my friends what I did. ... My friends also were asking me. I was answering them.*

Students might have the opportunity to work together with group work, and also might overcome their lack of learning by sharing what they had learned with each other. So, it implied that the students had carried out activities to provide multiple means of action and expression from the UDL principles. Also, it indicated that the students had the opportunity to communicate with their friends both by choosing the activity what they wanted and by sharing what they had learned. In addition, it could be noted that the students conducted peer counselling, which signals that these activities had a room for facilitating as well as fostering collaboration and community.

RETENTION

The retention allows students to prevent them from forgetting what they have learned and to transfer what they have learned to other situations. The aim of UDL is to ensure the student to become an expert learner. In order to be an expert learner, the information learned must be permanent. Thus, students can use what they have learned in new situations.

S6: ... *It keeps in mind that you're constantly repeating. I remember from there.*

Student 6, emphasized the repetition with the related subject as the reason for remembering what they had learned. In this study, the effect of repetition was emphasized by students. In addition, enriched activities related to the teaching of any subject were included in the UDL. In this way, the students had the opportunity to demonstrate what they had learned and to make up for their deficient learning and to consolidate what they had learned.

S3: ... *Shortcut of the multiplication. ... such as 4 times 1, 4. We were putting zeros on the side. I like that very much.*

Above, the expression of the students explained how to do the shortcut of the multiplication. Here, in fact, the UDL's guiding principles referred to the offering options for comprehension. Because the activities carried out in order to provide comprehension of the subjects in representation

were used to emphasize critical features, relationships and thus to be effective in providing retention. It indicated that UDL positively affected retention. This was understood from the student's

statement as regards how to make the subject of the shortcut of the multiplication taught in the 10th week of the study.

> S4: *... I loved the shortcut of the division. Zeros go, division ends.*
> S5: *... I was so scared I couldn't do the division. It was very simple when you taught it the short way.*
> Students: *... Multiply, subtract, down, do it again (showing with hand gestures).*

Above statements referred to the rhymes and hand gestures which were used to teach the critical features of the division. The student 4 said that rhyme about the subject remembered what he had to do about the subject and rhymes had a positive effect on retention. From the statements and the experiences of student 5 in the classroom, it could be deduced that the most difficult subject in the mathematics course was the division. The division process had to be done both in a sequence and also required cognitive skills such as division, multiplication, subtraction. It was quite natural that students with learning disabilities related to these procedures also had difficulties in dividing. In order to eliminate this difficulty, each stage of the division process was described in relation to a hand gesture. During the interview, all the students said that retention was positively affected by (a) the stages of the division process with hand gestures, (b) learning the stages of the division process, and (c) the use of body language in emphasizing the critical features.

> S1: *... I started to do it myself because I learned very well. I didn't get any help from anyone at my homework.*

Student 1 stated that s/he could do his / her work at home without help. We could conclude from this sentence that the student did not forgotten what s/he had learned at school and could also apply to his/her work at home.

ACTIVE PARTICIPATION

Students participate actively in activities to learn the subjects. For this, the students must first be willing. Accordingly, the planning and implementation of instruction will affect the active participation positively as it will attract student interest.

> *S4: ... Teacher, I started to participate more in course. I didn't care before.*

Above statement, it was mentioned that the lessons taught by using UDL increased the participation and interest. According to UDL, it is important that present the subjects to students with remarkable and appropriate options. Thus, student 4 stated that UDL contributed to the participation in the course and to be considered important of the course.

SELF – REGULATION

Pre-evaluation of the students help them to see their deficiencies. The student who detects the deficiency in himself/herself will be able to make self-regulation as s/he tries to eliminate these shortcomings. The student who tries to eliminate the deficiencies and make self-regulation will take a step towards becoming an expert learner.

> *S4: ... I gave myself four first, because I never listened to you. Then I started to give myself five, because I was listening. ... I had little help. Then I did it myself.*
> S3: *... I was looking at books before, but I couldn't learn. ... I gave myself four first. Then I listened to you, listened and started to give 5. ... I couldn't do it before, but now I'm doing it.*

Above statement, students talked about the effect of self-assessment on listening to the lesson. It showed that the students started listening to the lesson when they learned that they will evaluate themselves, and they wanted to give high marks. Here, students stated that they gave mark to the behaviour of listening to the course, not to the level of learning the subject. According to UDL,

students needed to be enabled to make self-regulation. The students had made such an arrangement by thinking that their listening behaviour was incomplete from the statement of student 3. This situation was also important in learning.

S2: ... *I didn't trust myself. You came and said that you will give yourself points before you explain the lesson. I've started to listen to you better. I listened better in order to win 5 points and to give myself 5 points.*...

Student 2's statements indicated that h/she did not trust h/her. However, it could be said that listening to the course to give a high mark, changed this situation. With this activity, it could be said that expectations and beliefs were tried to be encouraged.

S1: ... *I already gave you 5 points because I was listening very well. Then also I gave 5 points to myself.* ... *I was doing it at home and in school alone, without any help from anyone.* ... *I always started to do it myself because I learned very well. I never got any help from my homework.*

It could be said from the above statement that Student 1 was aware of why h/she should listen to the course. H/she thought that h/she had the right to get a high mark because h/she studied without help. From the statement, it could be said that the student had learned the subject.

CONCLUSIONS AND DISCUSSION

It was concluded that both the UDL and the teaching based on the curriculum had a large effect on the academic achievement of students in a mathematics course. However, it was concluded that UDL had a larger effect on increasing students' achievement in mathematics compared to teaching based on the curriculum. Achievement is related to recognition networks of the brain and to provide multiple means of representation principle. Because students achieve the highest level of learning when they can use what they have learned. This principle aims to enable the student to develop and reach sufficient maturity. When students have the opportunity to work on this principle, they become self-fulfilling learners (Nelson, 2014). Thomas, Garderen, Scheuermann and Lee (2015) concluded that when the development of mathematical language and thought was supported by the solutions offered by UDL, students could make sufficient progress in mathematics. Franz, Ivy and McKissick (2016) determined that the problem-solving instructions given in accordance with the UDL principles in mathematics course were effective in developing the students' problem-solving skills. Kennedy, Thomas, Meyer, Alves and Loyd (2014), in their study on the social studies course, found that the implementation of UDL in the classroom increased the students' success and decreased learning variances among the students. Hall, Cohen, Vue and Ganley (2015) concluded that UDL-based online applications developed with the strategic reader tool increased the achievement of students with disabilities. Yuzlu and Arslan (2017) found that UDL was more effective than the traditional method to improve students' learning of grammar structure in English teaching. According to all these findings and results, UDL could be used to increase the academic achievement of students in primary school mathematics courses.

When the findings of the study about the attitude towards mathematics course were examined, it was concluded that UDL had a large effect on increasing students' attitudes towards mathematics lesson. It had been concluded that teaching-based on curriculum was not effective in increasing students' attitudes towards mathematics. In addition, it was concluded that UDL did not have a significant effect on the students' attitudes towards mathematics course compared to teaching-based on the curriculum. It is very important to provide options for engagement in affective development because there is not a single tool suitable for all students, which resonates with one size, does not fit all as indicated by UDL. Creating a desire to learn in students is the most important thing that educators can do to make students become experts. It is necessary to provide support for each student to assess the level of difficulty, to be aware of the task of learning, and to help them deal with learning tasks and right balance should be established between supports (Meyer et al., 2014). In a lesson planned and processed in this way, students' attitudes towards the course may develop depending on the development of affective features. Felton (2012) determined that mathematics teachers who took and applied UDL and strategic planning training had changed their attitudes after in-service training and these changes were observed in class observations and document reviews.

According to all these results, UDL could be employed in primary school mathematics lessons in order to increase that the students' attitudes towards mathematics course.In this study, it was concluded that UDL increased the attention of students. According to the UDL, attention is related to affective networks. Affective networks enable us to evaluate models in participation in the course and to make emotional connections with them (Rose & Meyer, 2002). As stated by the students, it was seen that the classroom environment was arranged according to individual needs and also planning of the course by taking account into student diversity was effective in drawing attention. Jeon and Lee (2017) stated that various activities in which UDL was used in primary school English courses gave a good feeling to students and trainers, which leads them to attend to the course. And they stated that they helped them pay attention. As a result, UDL could be used to increase the attention of students in primary school mathematics courses.

The students stated that UDL increased the interest of students. In this study, it was possible to say that it was effective to work on the way to address the needs of each student in order to overcome learning variations and to offer alternatives in representation. This could also be understood from student expressions that providing options for recruiting interest served to achieve the UDL's principle of providing multiple means of engagement. This principle relates to affective networks. The types of affective reactions may vary from person to person, even over time and different situations in which the person is (Meyer et al., 2014). In addition, individuals are engaged in knowledge and activities that are relevant and valuable to their interests and goals. For these reasons, it is important to find alternative ways and to find ways of reflecting important and individual differences between students to attract students' attention (CAST, 2018).

Given information provided, it was concluded that the courses according to the UDL are aimed to be implemented in accordance with the principle of providing multiple means of engagement. Smith (2008) found that there was a positive relationship between student engagement and participation when faculty members used UDL strategies and technologies in their classrooms. Courey, Tappe, Siker and Lepage (2013) found that an UDL increased awareness of prospective teachers to evaluate their interests. Walker, McMahon, Rosenblatt and Arner (2017) explained that

educators could create engaging lessons that enhanced accessibility for all learners, including those with special needs, by combining increased reality with UDL principles. As a result, UDL could be used to increase the interest of students in primary school mathematics courses.

The results of this study indicated that the courses based on UDL to provide multiple representation. It was seen that variability was achieved in three networks of UDL and thus in three principles related to these networks. Staulters (2006) determined that the presentation of digitized word problems in various ways, such as painting, orientation and clues, increased the students' performance, participation and self-efficacy in a mathematics course. Izzo, Murray and Novak (2008) had shown that the application of UDL in higher education was suitable for both faculty and managers' increasing diversity of higher education and the need for multimodal education.

Taking into consideration of student differences also served multiple representations. It was concluded that this was applied in the study. Because it was attempted to reach the whole class and options were provided to understand and show the subject. Rao and Meo (2016) stated that the use of UDL so as to develop inclusive lesson plans for all students with and without disabilities would increase opportunities for all students to reach the same high standards. As a result, UDL could be used to provide multiple representations in primary school mathematics courses.

The students' statements indicated that UDL increased cooperation between students. It related to the UDL's principle of providing multiple means of action and expression that students chose

the works they wanted to do together with their friends, communicated with each other during the study and helped each other. This principle is associated with strategic networks. Students may vary in terms of their ability to implement higher-order strategies such as planning, organizing, monitoring progress, developing alternative

approaches, and seeking help when needed (Meyer et al., 2014).

In addition, the group work activities also served the principle of providing multiple means of engagement. According to UDL, it is necessary to foster collaboration and community in order to ensure that students sustain efforts and persistence. The organization of peer counseling can increase opportunities for students for one-on-one support. When carefully structured, such peer collaboration can significantly increase the support available to maintain participation (CAST, 2018). Kitanosako (2012), the application of UDL in primary mathematics courses in Japan, found that focusing on good balance for facilitating group dynamism had a positive effect on students. As a result, UDL could be used to increase the collaboration skills of students in primary school mathematics courses.

The one of principles of UDL is to provide multiple representation. It could be concluded from the students' statement that UDL increased the retention of knowledge. It was seen from the student expressions that the activities such as repetition, rhymes and bodily movements, exercises that were appropriate to the student level were effective in providing retention. In addition, the students said that they could do what they learned at home without help was an indication of this. The activities involving the rhymes and bodily movements were used to highlight the critical features and relationships of the subject. Nelson (2014) stated that it was necessary to emphasize the critical features and relations to bring preliminary information from the recognition stage to the usage stage. Emphasizing critical features and relationships is used to provide the principle of representation of the UDL. Although this principle was related to recognition networks, it showed that students did not forget to express this information despite the time elapsed. It was seen that this information was transferred

from the recognition stage to the usage stage with the appropriate activities and studies related to the subject. As a result, UDL could be used to ensure retention in primary school mathematics courses.

The multiple participation is important component of UDL. The students in the experimental group stated that they had the chance to engage in the lesson actively. It is critical in order to design learning environments that provide flexibility in the areas of participation, persist in the face of difficulty or failure and continue to develop self-knowledge so that each student can find a suitable path in the learning experience (Meyer et al., 2014).

Ensuring active participation in this study showed that UDL had been carried out to achieve the principle of providing multiple means of engagement. McGhie-Richmond and Sung (2012) found that UDL was a supportive framework to ensure the continuity of student participation through successful adaptations of teachers.

McGuire-Schwartz and Arndt (2007) found that UDL principles improved student learning and participation in meeting different student needs and making education more inclusive and effective. Staulters (2006) determined that the use of digitized word problems including pictures, orientation and clues increased the participation of students who had difficulty in solving vocabulary problems in mathematics. As a result, UDL could be used to ensure effective participation in primary school mathematics courses.

The self-regulation is one of the principles of multiple means of engagement. It was observed that UDL increases self-regulation skills. UDL allows students to make self-regulation. One way to ensure engagement in UDL is also to provide options for self-regulation. A successful approach requires students to provide very different skills to successfully manage their skills and the impacts of these skills and to provide adequate alternatives to support students with prior experience (CAST, 2018). Students gained self-regulation skills to measure their behaviour and their learning, to take responsibility for their own learning (Meyer et al., 2014). Yuzlu and Arslan (2017) found that UDL was more effective in developing students' self-

regulation skills than traditional teaching in English teaching. Lastly, it was concluded that conducting self-regulation skills related to affective networks positively influenced students' motivation and participation in the course and increased self-efficacy levels. He (2014) had shown that encouraging UDL through online lessons could reduce learners' concerns and support perceived satisfaction. Davies, Schelly and Spooner (2013) concluded that program-based UDL integration of

higher education students increased self-efficacy. As such, UDL could be used to increase the self-regulation skills of students in primary school mathematics courses. As a result, UDL is thought to be one of the effective methods in mathematic courses and its use is recommended.

This study was carried out in the 4th grade mathematics course. UDL can be applied at different teaching levels or in different courses. In this study, the effect of UDL model on academic achievement and attitude was examined. It can be investigated whether this model has an effect on other dependent variables. In addition to these, the suitability of educational programs and learning environments to the UDL can be investigated. Teachers' opinions about UDL can be obtained.

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