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THE EFFECTS OF MATHEMATICAL MODELLING ACTIVITIES ON THE DIFFICULTY PERCEPTION OF NUMBERS SENSE AND ACHIEVEMENT AMONG 4TH GRADERS[i]

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Abstract:

The purpose of the present research is investigating the effects of mathematical modelling activities on the difficulty perception of numbers sense, which is perceived as difficult by primary school 4th grade students, and achievement. The problem statement of the present research was formed as "*Does mathematical modelling strategy has any effects on 4th grade students' levels of difficulty perceptions and their achievement related number sense learning field?*" The present research was conducted in accordance with quantitative research methods in two steps. The first step was conducted in accordance with survey model on 207 students, who studied in Selcuklu district of the province of Konya in the spring semester of 2013-2014 School Year. The second step was also conducted on 61 students from two equal classes of Esrefoglu Primary School in accordance with experiment model with pre-test-post-test and control group. In order to collect data for the present research, "*Numbers Learning Domain Achievement and Difficulty Perception Scale (NLDADPS) Form A and Form B*" were employed as pre-test and post-test on experiment and control groups, "*Observation Form for the Evaluation of the Experimental Procedure*" was employed to evaluate the implementation on the experiment group, and "*Observation Form for the Evaluation of the Problem Solving Activities Conducted in Control Group*" was employed to evaluate the teaching conducted on control group. All of the scales were developed by the researcher. It was found that mathematical modelling activities were more effective on procedural knowledge and concept-procedure connections dimensions of the topics than traditional problem solving activities, and enabled developing positive attitudes towards mathematics and

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contributed to the development of metacognitive skills required for establishing concept-procedure connections.

Keywords: difficulty perception, mathematical modelling, mathematical modelling activities

1. Introduction

Even mathematics subject as a whole is considered as a difficult subject by students, this is not true for all topics and concepts; and not at the same level. Some topics are defined as more difficult than others by the students. Studies on the topics that are easy for students, and students have difficulty in learning are considered as important to guide education, planners and teachers (Gürbüz et al., 2011). For this purpose, many studies have been conducted to define the topics that students have difficulty in learning, and the possible reasons for these (Tall & Razali, 1993; Baker, 1996; Aydın, 1998; Zachariades, Christou & Papageorgiou, 2002; Durmuş, 2004a; Dikici & İşleyen, 2004; Yenilmez, 2007; Tatar, Okur & Tuna, 2008; Baki and Kutluca, 2009b; Gürbüz, Toprak, Yapıcı & Doğan, 2011). These difficulties are mostly considered to have resulted from "*deficiencies in basic concepts/pre-learning, inabilities in problem-solving and lack of algebraic, geometrical and trigonometric skills*" (Tall, 1993).

Durmuş (2004a), who stated that no studies on the topics that were more problematic for students, students had problems in understanding and the reasons for these problems at primary and secondary education levels were conducted in Turkey, detected the difficulty indices of all topics in secondary school mathematics curriculum with a Likert type questionnaire in his study carried to determine the topics that students perceive as difficult in mathematics classes and the reasons for difficulties and reported in accordance with the interviews conducted with students that lack of motivation and the abstractness of the topics were the two important reasons. He also conducted a similar study with primary school students in order to define the learning difficulties in primary school mathematics and their reasons in which interviewed students in order to question the reasons of difficulties and reported that students defined the topics as complex, meaningless, and they didn't know where to use what they learnt (Durmuş, 2004b).

Lacking problem solving skills, as a commonly encountered problem in mathematics learning and teaching, is considered as the basis of these difficulties. The purpose of many activities intended for problem solving, either routine or not, is overcoming problems encountered in daily life using alternative methods. At this point, the vision of primary education mathematics curriculum was re-arranged as '*raising individuals, who have such skills as using mathematics in their lives as necessary, establishing* *the relationship between real life situations and mathematics, producing alternative solutions to the problems they encounter, thinking analytically, and reasoning and associating"* (Ministry of National Education, 2009). However, it is observed that mathematics course books rarely include problematic situations that can be encountered in daily life. Yet, providing students with experiences in which they can study with mathematical situations that require different interpretations, and enabling them sharing these experiences with their peers are of utmost importance. One way for students to acquire these skills is making use model-establishing activities that involve mathematical modelling (Lesh and Doerr, 2003; English and Watters, 2005).

Mathematical modelling activities are defined as problem solving activities in which teachers and students reason on real life situations, define, explain and estimate about these situations, discover, expand and correct their own mathematical structures, and meanwhile develop models by means of explain, test and review their mathematical thinking (Kaiser & Sriraman, 2006; Eric, 2008; Doerr and O'Neill, 2011).

Previous studies have reported that students, who work with modelling activities, can successfully overcome multi-component complex problems that reveal thoughts and develop their existing understanding (English, 2006). Modelling activities help students use various interpretations and methods in authentic content and develop internal motivation (Mousoulides et al., 2007). Additionally, as students mathematize patterns, relations or rules, they engage in important upper-level mathematical thinking processes, such as explaining, analysing, building and reasoning (Lesh and Doerr, 2003). Therefore, unlike the traditional approach used in mathematics teaching, modelling activities provide students with rich learning opportunities by encouraging them to understand their previous learning by thinking more deeply on them and to produce more generalizable solutions as they re-build them (English, 2003, 2006).

Mathematical modelling activities are believed to have positive contributions to students' difficulty perceptions of mathematics and the mathematics topics, and their achievement levels. Accordingly, the present research is planned to be studied in two dimensions. The first step is detecting the topics in numbers learning domain that students perceive as difficult and define their achievement levels; and the second step is investigating the effects of mathematical modelling activities on the difficulty perception and achievement levels in the topics that are perceived as difficult.

The problem statement of the present research was formed as *"Does mathematical modelling strategy has any effects on 4th grade students' levels of difficulty perceptions and their achievement related number sense learning field?"*

2. Method

2.1. Research Design

The present research is conducted in two steps in accordance with quantitative research methods. The first step was conducted in accordance with survey model in order to detect the topics in the numbers learning domain in the primary education mathematics curriculum (Ministry of National Education, 2009) that are perceived as difficult by students. The purpose of survey model is describing and defining a case that existed in the past or still exists as it is. There are things that are wanted to be known, but what is important is observing that appropriately and define it (Karasar, 2006). The second step employed experiment model with pre-test-post-test and control group. Table 1, presents the experimental design adopted in the present research through symbols.

Table 1: Experimental design of the research

Groups	Pre-test	Independent Variable	Post-test
G_E	NLDADPS	Process projected in the curriculum + Mathematical Modelling Activities (9 Weeks)	NLDADPS
G_C	NLDADPS	Problem-solving activities projected in the curriculum (9 Weeks)	NLDADPS

2.2. Participant Characteristics and Sampling Procedures

The first step of the present research was conducted on 100 female and 107 male, the total of 207 students, who studied 4th grade in two state schools in Selcuklu district of Konya province. These two schools were selected randomly among schools that had 4th grade education and classes.

The work group of the second step of the present research consists of 61 students, who studied in 4/A and 4/C classes of Esrefoglu Primary Schools in Selcuklu district of Konya province, which serves under the Ministry of National Education. Of these students, 30 formed the experiment group and 31 formed the control group. The students in experiment and control groups were taken in terms of mathematics achievement as equivalent based on their school reports, and the remarks of their teachers and the managers of their schools.

2.3. Data Collection Tools

In order to collect data for the present research, "*Numbers Learning Domain Achievement and Difficulty Perception Scale (NLDADPS) Form A and Form* B" were employed as pre-test and post-test on experiment and control groups, "*Observation Form for the Evaluation of the Experimental Procedure*" was employed to evaluate the implementation on the experiment group, and "*Observation Form for the Evaluation of the Problem Solving*

Activities Conducted in Control Group" was employed to evaluate the teaching conducted on control group. All of the scales were developed by the researcher.

NLDADPS, Form A and Form B consists of two parts. 'Form A' consists of questions prepared for achievement test, and 'Form B' consists of the questions in 'Form A' besides a standard question with tick boxes below those questions, intended to receive students remarks on the easiness or difficulty on the question. Students, who answered questions in Form A, are not asked to answer the same questions in Form B, but just to present their remarks on the easiness of difficulty of the questions through a Likert type scale.

While developing the scale, previous studies on students' achievement and difficulty perceptions of the numbers learning domain were studied and the dimensions of the scale were defined accordingly. The dimensions were defined based on Van de Wella (2004)'s idea that teaching that suits the structure of mathematics should be intended for three purposes. Accordingly, teaching that suits the structure of mathematics should help students with;

1. Understanding the conceptual knowledge,
2. Understanding the procedural knowledge,
3. Establishing connections between concepts and procedures.

Based on this basic purpose, the dimensions of the scale were defined as conceptual knowledge, procedural knowledge and concept-procedure connection. According to the related literature, conceptual knowledge is classified as "*Obvious Conceptual Knowledge*" and "*Latent Conceptual Knowledge*". According to this classification, obvious conceptual knowledge refers to processes, such as producing definitions, choosing the correct definition among the provided definitions, evaluating judgements, defining concepts related to the content, and explaining the reasons of the provided procedure; while latent conceptual knowledge refers to such processes as, making naming and classifying targeted choices, deciding on the correctness of procedure process, evaluating sample procedure, converting between different presentation formats and comparing multiplicities (Rittle Johnson and Schneider, 2014). Accordingly, conceptual knowledge dimension items of the scale were developed based on obvious conceptual knowledge evaluation criteria, taken its suitability with students' level into and considering that conceptual knowledge can be discriminated more distinctively thorough procedural knowledge. The scale was developed in accordance with the three steps suggested by Tracy and Gibson (2005);

First step: Previous studies on the mathematical achievement and difficulty perception were studied through literature review and the process of mathematical difficulty perception and evaluation was defined.

Second step: Scale items were developed in this step. This procedure was conducted in five steps: (1) Related literature was studied and it was decided that answer formats of the developed scale were varied as questions that require open-ended, multiple choice and short answers, (2) an item pool of first forms of the items was created, and in this trial scale 12 questions for each topic, the total of 82 questions were included, (3) each item was re-evaluated considering the scale dimensions for content validity, expert opinions were taken in this step, and validity indices were calculated with Lawshe (1975) technique, (4) each item was studied in order to detect any uncertainty in the content of problem/question, and expert opinions were taken in this step as well, (5) items were tried on a broad sample, with this purpose, trial scale was conducted on the 207 students, who formed the work group of the present research.

Third step: In this step, analyses were conducted in three steps: (1) item analysis was conducted; (2) content analysis was conducted in order to present the content validity of the scale items and the scale, (3) reliability studies were conducted for the scale.

In the analysis of the first step of the research, descriptive statistics techniques used by Durmuş (2004a), such as difficulty index and arithmetic average (X) were utilized. In the analysis of the second step, the relations between pre-test and post-test scores were investigated. Independent samples t-test and paired samples t-test were utilized in this procedure. The significance of the differences in the analyses was tested at (*p*) 0,05 level.

2.4. Experimental Manipulations or Interventions

Before starting the implementations of the research, necessary permissions were received from the officials, pilot implementations were conducted and the teachers, who carried the implementations, were informed.

During the preparation classes in the implementation process, students were informed about the mathematical modelling activities in general terms. In these classes, students were provided with steps of mathematical Modelling Activities (Figure 1), they were informed about this process and that they would act in accordance with the steps presented here during mathematical modelling activities.

While planning mathematical modelling activities during experimental procedure, the modelling steps below suggested by Blum and Niss (1989) and Lesh and Doerr (2003) were utilized.

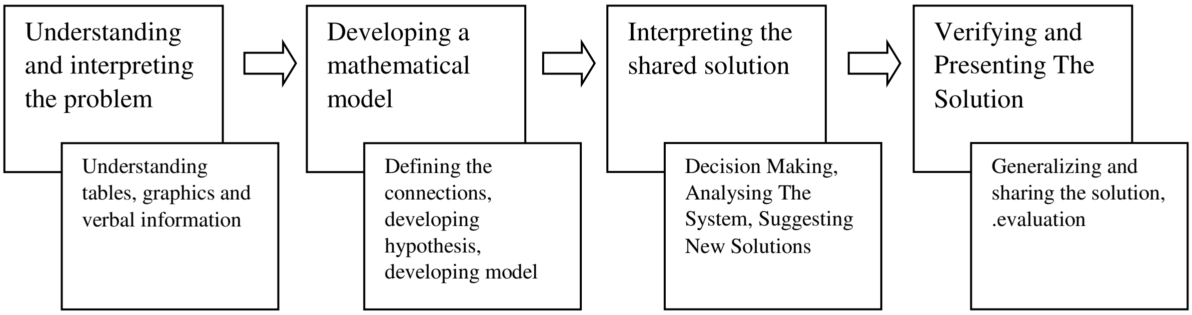

Figure 1: Mathematical Modelling Steps

The researcher prepared real life problems in order to use in the teaching process with Mathematical Modelling Activities, and the following steps were followed by the teacher during the implementation of the activities:

1. The teacher taught the lessons reminding the students the implementation process of mathematical modelling activities, which both the teacher and the students had.
2. The teacher made the students read the problems in the work sheets in due course, and the teacher made stories of the problems when necessary in order to help students understand the problems.
3. Students told each problem first to their group mates, then the group representative, a different student in each activity, loudly to the whole class. Additionally, students answered teacher's guiding questions related to the problem.
4. In groups, students discussed which of the helping elements, such as tables, graphics, images, numerical axes, and figures, could be used in models, and used the elements they decided on.
5. Students were guided for model development to solve the problems, by making them establish connections between important concepts in the problems and the other associated concepts, and asking them questions about the procedures they would use and their reasons for using those.
6. Students were made to discuss the model or models they developed for the solution, then group representative, again different students in each activity, introduced the model they developed. These developed models were discussed in terms of their similarities and differences with the guidance of the teacher, and they tried to find out the best model for the solution. The selected model was revised and re-arranged.
7. At the end of each activity, students were asked to write one letter each to the quasi people who encountered the problem, and a report describing their models.

8. Students were asked to develop problems similar to the ones in the activities, and to check whether the model they developed provided a solution to that problem as well.
9. The students discussed in which other situations the model they developed could be used, and were asked to evaluate the modelling process.

During the total of nine-week process (27 class hours) of activities, students worked on 9 real life problems in groups. The groups were formed of 4 students based on their mathematics subject school report score as one student with high, two students with medium and one student with low scores.

Control group lessons were planned according to 4th Grade Mathematics Teacher's Book. Teachers and students conducted problem posing and solving activities, as they did before.

3. Findings and Interpretations

3.1 Findings on the First Step of the Research

Table 2: Findings on the difficulty perception of numbers learning domain topics

Learning domain	Sub-learning domains	Dimensions	Difficulty index averages	
NUMBERS	Natural Numbers	Conceptual Knowledge	3.26	5,00
		Procedural Knowledge	5,43	
		Concept-Procedure Connection	6,31	
	Addition	Conceptual Knowledge	3,00	4,26
		Procedural Knowledge	5,40	
		Concept-Procedure Connection	4,39	
	Subtraction	Conceptual Knowledge	1,62	3,98
		Procedural Knowledge	3,67	
		Concept-Procedure Connection	6,65	
	Multiplication	Conceptual Knowledge	1,53	6,02
		Procedural Knowledge	7,22	
		Concept-Procedure Connection	9,31	
	Division	Conceptual Knowledge	1,53	6,99
		Procedural Knowledge	9,04	
		Concept-Procedure Connection	10,39	
	Fractions	Conceptual Knowledge	2,20	6,92
		Procedural Knowledge	4,84	
		Concept-Procedure Connection	13,72	
	Decimal Fractions	Conceptual Knowledge	3,10	5,75
		Procedural Knowledge	4,74	
		Concept-Procedure Connection	9,42	

As presented in Table 2, according to the averages of all dimensions of the sub-learning domains, difficulty perception indices are; '5.00' for natural numbers, '4.26' for addition, '3.98' for subtraction, '6.02' for multiplication, '6.99' for division, '6.92' for fractions, and '5.75' for decimal fractions. According to these findings, division is perceived as the most difficult topic by 4th graders, and this is respectively followed by fractions, multiplication, decimal fractions, natural numbers, addition and subtraction.

Table 3: Findings on the Achievement Levels of Numbers Learning Domain Topics

Learning domain	**Sub-learning domains**	**Dimensions**	**Achievement averages**	
NUMBERS	Natural Numbers	Conceptual Knowledge	3.60	3,59
		Procedural Knowledge	3,58	
		Concept-Procedure Connection	3,60	
	Addition	Conceptual Knowledge	4,43	3,46
		Procedural Knowledge	3,12	
		Concept-Procedure Connection	2,84	
	Subtraction	Conceptual Knowledge	4,20	3,31
		Procedural Knowledge	3,52	
		Concept-Procedure Connection	2,91	
	Multiplication	Conceptual Knowledge	3,91	3,19
		Procedural Knowledge	3,10	
		Concept-Procedure Connection	2,56	
	Division	Conceptual Knowledge	4,06	3,10
		Procedural Knowledge	2,90	
		Concept-Procedure Connection	2,34	
	Fractions	Conceptual Knowledge	3,74	3,26
		Procedural Knowledge	3,49	
		Concept-Procedure Connection	2,55	
	Decimal Fractions	Conceptual Knowledge	3,52	3.34
		Procedural Knowledge	3,72	
		Concept-Procedure Connection	2,80	

As presented in Table 3, according to the averages of all dimensions of the sub-learning domains, achievement levels are '3.59' for natural numbers, '3.46' for addition, '3.31' for subtraction, '3.19' for multiplication, '3.10' for division, '3.26' for fractions, and '3.3.4' for decimal fractions. According to these findings, students were least successful in division, which is followed respectively by multiplication, fractions, subtraction, decimal fractions, addition and natural numbers.

Another interesting finding of the present research was that, even two students got full marks from the achievement scale (Form A), they stated that they perceive the same questions as difficult in the difficulty perception scale (Form B). As for the reason for this, one of the students said *'I don't like mathematics, so I think all questions are difficult'*, while the other said *'mathematics questions are difficult, and I like achieving the* *difficult'*. The opposite case was experienced with one student, who got bad scores on the achievement scale (Form A) and stated that he perceived the same questions as easy in the difficulty perception scale (Form B). When he was asked about that, he said *'So be it, easy for me'*. According to these findings, even students generally have difficulty in topics they achieve less, the differences in beliefs, attitudes, and self-perceptions of students can result in some different findings.

3.2 Findings on the Second Step of the Research

Table 4: NLDADPS (Form B) T-test Analysis Results for the Comparison of Difficulty Perception

Pre-test Scores

Sub-Learning Domain	Test	Dimension	Group	N	X	S	Sd	T	P
Multiplication	Pre- Test	Conceptual Knowledge	Experiment	30	1,14	0,42	59	-0,187	,85
			Control	31	1,16	0,45			
		Procedural Knowledge	Experiment	30	1,32	0,45	59	-0,496	,62
			Control	31	1,38	0,52			
		Concept-Procedure Con.	Experiment	30	1,30	0,58	59	-0,432	,66
			Control	31	1,37	0,69			
Division	Pre- Test	Conceptual Knowledge	Experiment	30	1,14	0,40	59	-0,016	,98
			Control	31	1,14	0,45			
		Procedural Knowledge	Experiment	30	1,44	0,60	59	-0,046	,96
			Control	31	1,43	0,56			
		Concept-Procedure Con.	Experiment	30	1,43	0,77	59	-0,191	,85
			Control	31	1,46	0,63			
Fractions	Pre- Test	Conceptual Knowledge	Experiment	30	1,13	0,39	59	-0,702	,48
			Control	31	1,20	0,41			
		Procedural Knowledge	Experiment	30	1,41	0,72	59	-0,984	,32
			Control	31	1,25	0,56			
		Concept-Procedure Con.	Experiment	30	1,60	0,83	59	-0,094	,92
			Control	31	1,58	0,77			

As presented in Table 4, there aren't significant differences between pre-test scores of experiment and control groups, in terms of the dimension of sub-learning domain (p>0,05). Accordingly, experiment and control groups are equal in terms of their pre-test difficulty perceptions of multiplication, division and fractions sub-learning domains.

Table 5: NLDADPS (Form A) T-test analysis results for the comparison of Achievement Level

Pre-test scores

Sub-Learning Domain	**Test**	**Dimension**	**Group**	**N**	**X**	**S**	**Sd**	**T**	**P**
Multiplication	Pre-Test	Conceptual Knowledge	Experiment	30	4,10	0,72	59	0,042	,96
			Control	31	4,10	0,67			
		Procedural Knowledge	Experiment	30	3,21	1,15	59	0,604	,54
			Control	31	3,40	1,25			
		Concept-Procedure Con.	Experiment	30	3,11	1,08	59	-0,523	,60
			Control	31	2,96	1,13			
Division	Pre-Test	Conceptual Knowledge	Experiment	30	4,32	0,56	59	-0,901	,37
			Control	31	4,17	0,72			
		Procedural Knowledge	Experiment	30	3,26	1,20	59	-0,312	,75
			Control	31	3,16	1,23			
		Concept-Procedure Con.	Experiment	30	2,80	1,14	59	-1,895	,07
			Control	31	2,27	1,01			
Fractions	Pre-Test	Conceptual Knowledge	Experiment	30	3,90	1,01	59	0,275	,78
			Control	31	3,96	0,91			
		Procedural Knowledge	Experiment	30	3,70	0,86	59	-1,398	,16
			Control	31	3,40	0,79			
		Concept-Procedure Con.	Experiment	30	2,76	1,30	59	-1,719	,09
			Control	31	2,27	0,90			

As presented in Table 5, there aren't significant differences between pre-test scores of experiment and control groups, in terms of the dimension of sub-learning domain (p>0,05). Accordingly, experiment and control groups are equal in terms of their pre-test achievement levels of multiplication, division and fractions sub-learning domains.

Table 6: NLDADPS (Form B) T-test analysis results for the comparison of Difficulty Perception

Post-test scores

Sub-Learning Domain	**Test**	**Dimension**	**Group**	**N**	**X**	**S**	**Sd**	**T**	**P**
Multiplication	Post- Test	Conceptual Knowledge	Experiment	30	1,08	0,28	59	-0,864	,39
			Control	31	1,14	0,27			
		Procedural Knowledge	Experiment	30	1,10	0,18	59	-2,970	,00
			Control	31	1,34	0,40			
		Concept-Procedure Con.	Experiment	30	1,11	0,21	59	-1,440	,15
			Control	31	1,27	0,56			
Division	Post- Test	Conceptual Knowledge	Experiment	30	1,08	0,27	59	-0,058	,95
			Control	31	1,08	0,24			
		Procedural Knowledge	Experiment	30	1,11	0,37	59	-2,386	,02
			Control	31	1,36	0,43			

		Concept-Procedure Con.	Experiment	30	1,13	0,34	59	-2,013	,04
			Control	31	1,40	0,65			
Fractions	Post- Test	Conceptual Knowledge	Experiment	30	1,11	0,31	59	-0,285	,77
			Control	31	1,13	0,28			
		Procedural Knowledge	Experiment	30	1,10	0,25	59	-1,403	,16
			Control	31	1,23	0,44			
		Concept-Procedure Con.	Experiment	30	1,20	0,50	59	-1,864	,05
			Control	31	1,50	0,73			

As presented in Table 6, there are statistically significant differences between experiment and control groups, in terms of multiplication operational knowledge dimension (t= -2,970 and p<0,05), division operational knowledge (t= -2,386 and p < 0,05) and conceptual knowledge (t= -2,013 and p < 0,05) and fractions concept-operation connection dimensions (t= -1,864 and p ≤ 0,05) difficulty perception averages, which are lower in favour of experiment group.

Table 7: NLDADPS (Form A) T-test Analysis Results for the Comparison of Achievement Level

Post-test Scores

Sub-Learning Domain	Test	Dimension	Group	N	X	S	Sd	T	P
Multiplication	Post-Test	Conceptual Knowledge	Experiment	30	4,30	0,75	59	0,991	,32
			Control	31	4,11	0,68			
		Procedural Knowledge	Experiment	30	4,00	0,98	59	2,236	,02
			Control	31	3,33	1,34			
		Concept-Procedure Con.	Experiment	30	3,75	1,12	59	1,751	,08
			Control	31	3,17	1,40			
Division	Post-Test	Conceptual Knowledge	Experiment	31	4,38	0,81	59	1,390	,17
			Control	30	4,09	0,83			
		Procedural Knowledge	Experiment	31	3,96	0,95	59	2,428	,01
			Control	30	3,25	1,31			
		Concept-Procedure Con.	Experiment	31	3,55	1,38	59	2,150	,03
			Control	30	2,77	1,43			
Fractions	Post-Test	Conceptual Knowledge	Experiment	31	4,26	0,86	59	1,240	,22
			Control	30	3,93	1,19			
		Procedural Knowledge	Experiment	31	4,04	0,66	59	2,362	,02
			Control	30	3,55	0,91			
		Concept-Procedure Con.	Experiment	31	3,65	1,26	59	2,824	,00
			Control	30	2,66	0,46			

As presented in Table 7, there are statistically significant differences between experiment and control groups in terms of multiplication procedural knowledge (t= 2,236 and p<0,05), division procedural knowledge (t= 2,428 and p<0,05) and concept-procedure connection (t= 2,150 and p<0,05), fractions procedural knowledge (t= 2,362 and p<0,05) and concept-procedure connection dimensions (t= 2,824 and p<0,05) achievement levels averages, which are higher in favour of experiment group.

Table 8: NLDADPS (Form B) T-test Analysis Results for the Comparison of Difficulty Perception

Pre-Test and Post-test Scores

Sub-Learning Domain	**Test**	**Dimension**	**Test**	**N**	**X**	**S**	**Sd**	**T**	**P**
Multiplication	Experiment	Conceptual Knowledge	Pre-Test	30	1,14	0,42	29	0,990	,33
			Post-Test	30	1,08	0,28			
		Procedural Knowledge	Pre-Test	30	1,32	0,45	29	2,873	,00
			Post-Test	30	1,10	0,18			
		Concept-Procedure Con.	Pre-Test	30	1,30	0,58	29	2,626	,01
			Post-Test	30	1,16	0,21			
	Control	Conceptual Knowledge	Pre-Test	31	1,16	0,45	30	0,338	,73
			Post-Test	31	1,14	0,27			
		Procedural Knowledge	Pre-Test	31	1,38	0,52	30	0,425	,67
			Post-Test	31	1,34	0,40			
		Concept-Procedure Con.	Pre-Test	31	1,37	0,69	30	1,793	,08
			Post-Test	31	1,27	0,56			
Division	Experiment	Conceptual Knowledge	Pre-Test	30	1,14	0,40	29	1,439	,16
			Post-Test	30	1,08	0,27			
		Procedural Knowledge	Pre-Test	30	1,44	0,60	29	2,549	,01
			Post-Test	30	1,11	0,37			
		Concept-Procedure Con.	Pre-Test	30	1,43	0,77	29	1,964	,05
			Post-Test	30	1,13	0,34			
	Control	Conceptual Knowledge	Pre-Test	31	1,14	0,45	30	1,438	,16
			Post-Test	31	1,08	0,24			
		Procedural Knowledge	Pre-Test	31	1,43	0,56	30	0,605	,55
			Post-Test	31	1,36	0,43			
		Concept-Procedure Con.	Pre-Test	31	1,46	0,63	30	0,391	,69
			Post-Test	31	1,40	0,65			
Fractions	Experiment	Conceptual Knowledge	Pre-Test	30	1,13	0,39	29	0,245	,80
			Post-Test	30	1,11	0,31			
		Procedural Knowledge	Pre-Test	30	1,41	0,72	29	2,316	,02
			Post-Test	30	1,10	0,25			
		Concept-Procedure Con.	Pre-Test	30	1,60	0,83	29	2,283	,03
			Post-Test	30	1,20	0,50			
	Control	Conceptual Knowledge	Pre-Test	31	1,20	0,41	30	0,983	,33
			Post-Test	31	1,13	0,28			
		Procedural Knowledge	Pre-Test	31	1,25	0,56	30	0,205	,83
			Post-Test	31	1,23	0,44			
		Concept-Procedure Con.	Pre-Test	31	1,58	0,77	30	0,530	,60
			Post-Test	31	1,50	0,73			

As presented in Table 8, difficulty perception averages are lower among experiment group after the experimental procedure for all topics, which were perceived as difficult before the experimental procedure. These decreases are statistically significant in multiplication procedural knowledge and concept-procedure connection, division procedural knowledge and concept-procedure connection, and fractions procedural knowledge and concept-procedure connection dimensions ($p<0,05$). There were also decreases in the difficulty perception averages of all topics after the procedure conducted in control group, however none of the differences between the pre-test and post-test averages of control group students were statistically significant ($p>0,05$).

Table 9: NLDADPS (Form A) T-test Analysis Results for the Comparison of Achievement Level

Pre-test and Post-test Scores

Sub-Learning Domain	**Test**	**Dimension**	**Test**	**N**	**X**	**S**	**Sd**	**T**	**P**
Multiplication	Experiment	Conceptual Knowledge	Pre-Test	30	4,10	0,72	29	-1,383	,17
			Post-Test	30	4,30	0,75			
		Procedural Knowledge	Pre-Test	30	3,21	0,98	29	-3,819	,00
			Post-Test	30	4,00	1,08			
		Concept-Procedure Con.	Pre-Test	30	3,11	1,12	29	-2,850	,00
			Post-Test	30	3,75	0,21			
	Control	Conceptual Knowledge	Pre-Test	31	4,10	0,68	30	-0,083	,93
			Post-Test	31	4,11	0,68			
		Procedural Knowledge	Pre-Test	31	3,40	1,25	30	0,300	,76
			Post-Test	31	3,33	1,34			
		Concept-Procedure Con.	Pre-Test	31	2,96	1,13	30	-0,848	,40
			Post-Test	31	3,17	1,40			
Division	Experiment	Conceptual Knowledge	Pre-Test	30	4,32	0,56	29	-0,367	,71
			Post-Test	30	4,38	0,81			
		Procedural Knowledge	Pre-Test	30	3,26	1,20	29	-2,719	,01
			Post-Test	30	3,96	0,95			
		Concept-Procedure Con.	Pre-Test	30	2,80	1,14	29	-2,726	,01
			Post-Test	30	3,55	1,38			
	Control	Conceptual Knowledge	Pre-Test	31	4,17	0,72	30	0,560	,58
			Post-Test	31	4,09	0,83			
		Procedural Knowledge	Pre-Test	31	3,16	1,23	30	-0,344	,73
			Post-Test	31	3,25	1,31			
		Concept-Procedure Con.	Pre-Test	31	2,27	1,01	30	-1,944	,06
			Post-Test	31	2,77	1,43			
Fractions	Experiment	Conceptual Knowledge	Pre-Test	30	3,90	1,01	29	-1,649	,11
			Post-Test	30	4,26	0,86			

		Procedural Knowledge	Pre-Test	30	3,70	0,86	29	-1,749	,09
			Post-Test	30	4,04	0,66			
		Concept-Procedure Con.	Pre-Test	30	2,76	1,30	29	-3,248	,00
			Post-Test	30	3,65	1,26			
	Control	Conceptual Knowledge	Pre-Test	31	3,96	0,91	30	0,144	,88
			Post-Test	31	3,93	1,19			
		Procedural Knowledge	Pre-Test	31	3,40	0,79	30	-0,812	,42
			Post-Test	31	3,55	0,91			
		Concept-Procedure Con.	Pre-Test	31	2,27	0.90	30	-1,545	,13
			Post-Test	31	2,66	1,46			

As presented in Table 9, achievement level averages are higher among experiment group after the experimental procedure for all topics, which were perceived as difficult before the experimental procedure. These increases are statistically significant in multiplication procedural knowledge and concept-procedure connection, division procedural knowledge and concept-procedure connection, and fractions concept-procedure connection dimensions ($p<0,05$). There were also increases in the achievement level averages of all topics after the procedure conducted in control group, however none of the differences between the pre-test and post-test averages of control group students were statistically significant ($p>0,05$).

4. Discussion and Conclusion

In the first step of the research, there were differences in rankings in terms of difficulty perception and achievement, yet especially the first three topics (division, multiplication and fractions) were common in both terms. Accordingly, division, multiplication and fractions are the topics that students have most difficulty in numbers learning domain. This finding is in agreement with some previous similar studies in the related literature (Toluk, 2002; Ardahan and Ersoy, 2003; Soylu, 2005; Durmuş, 2005; Birgin and Gürbüz, 2009; Mısral, 2009; Işık, 2011; Kubanç, 2012).

Another finding of the first step of the present research was obtained by studying the scale in terms of its dimensions. Accordingly, students have less difficulty in conceptual knowledge dimension, while they have more difficulty in procedural knowledge dimensions. This finding is in agreement with Baykul (2006)'s finding related to conceptual knowledge that there aren't any concepts that students in the first five years of primary education will have difficulty in learning among the mathematical concepts that are aimed to teach to these students.

Pre-learned conceptual knowledge is the basis of procedural knowledge. Conceptual knowledge covers procedural knowledge, as procedural knowledge covers conceptual knowledge. Therefore, there isn't a distinct line separation procedural and conceptual knowledge (Baki, 1998). Concepts are for procedures that advance step-by-step in mental presentations (Van de Walle, 2004). In other words, conceptual knowledge covers procedural knowledge and is the pre-condition for it. According to the findings on the conceptual knowledge and procedural knowledge dimensions in this context, the difficulties students have is procedural knowledge dimension result from that the relations between concepts cannot be established adequately, and students have knowledge of concepts only at cognitive knowledge level that includes rules and generalizations.

Students have most difficulty in concept-procedure connection dimension. The failure in acquiring conceptual basis of procedural knowledge results in failure in establishing the connection between procedural knowledge and concepts, establishing models, and deciding in where to use the procedures, which presents itself as failure in problem-solving (Baykul, 2006). This difficulty experienced in concept-procedure connection dimension in this context, result in difficulty in problem solving and developing processes in all topics of numbers learning domain. Because problem-solving is a scientific method as well, it requires critical thinking, creative and reflective thinking and use of analysis and synthesis skills (Reusser and Stebler, 1997; Cited in: Soylu and Soylu, 2006). From this aspect, the difficulty in concept-procedure connection results from the deficiencies related to upper-level cognitive skills. Among the reasons for failure, that we cannot provide students with help in relational understanding plays an important role (Baykul, 2006).

According to the findings obtained in the second part of the present research, mathematical modelling activities conducted on the experiment group were more effective than the problem-solving activities conducted in control group in both procedural knowledge and concept-procedure connection dimensions. As stated in the findings of the first of the present research, procedural knowledge cannot be separated from conceptual knowledge distinctly, and considering that these concepts and connections between procedures underlie the procedural knowledge, we can claim that mathematical modelling activities are pretty effective in providing concept-procedure connection.

Another finding of the present research is that, in the class on which mathematical modelling activities were conducted, students were more willing to participate in the lesson, enjoyed implementing activities, and the teacher was more willing to teach the lesson. Accordingly, we can claim that mathematical modelling activities are also effective in developing positive attitudes towards mathematics.

Consequently, it can be stated that mathematical modelling activities enable students be active in learning process more than traditional problem-solving activities (Doruk and Umay (2011), result in developing positive attitudes towards mathematics

(Boaler, 2001; Korkmaz, 2010; Mehraein and Gatabi, 2014a), is a very effective method in establishing connections between concepts and procedures and acquiring meta-cognitive skills (English and Wattters, 2004; Blum and Borromeo Ferri, 2009; Olkun, Şahin, Dikkartın and Gülbağcı, 2009; Sağırlı, 2010; Hıdıroğlu, 2010).

The findings of the present research are on the effects of mathematical modelling activities on mostly cognitive processes. Further studies can be conducted on both cognitive and affective processes. Teaching with mathematical modelling activities can be compares with other methods, and the differences of modelling process can be presented more clearly. Considering that mathematical modelling competencies are more process oriented that being product oriented, therefore process-oriented evaluations instead of studying the modelling products can be provided.

Through the use of mathematical modelling activities in daily mathematics classes, students can develop modelling skills, and achieve in modelling a real-life problem on their own (Maaß, 2005). Accordingly, for the students to be more successful in problem-solving, mathematical modelling activities can be included in the curriculum more in order to develop students' modelling skills.

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