The Effect of Time on Difficulty of Learning (The Case of Problem Solving with Natural Numbers)

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ABSTRACT

The main purpose of this study is to determine the time-dependent learning difficulty of "solving problems that require making four operations with natural numbers" of the sixth grade students. The study, adopting the scanning model, consisted of a total of 140 students, including 69 female and 71 male students at the sixth grade. Data was collected using an assessment tool consisting of 12 open-ended questions. The findings show that the learning group consisting of 140 students was behind the value that is closest to the full learning level by a score of 0.011. While the female students reached the lower limit of 0.989 specified for the full learning level in a period of 2.55 course hours, the male students reached this limit in 2.87 course hours. The learning amount of 0.999, which is the closest value to the full learning level, was reached by the learning group in a period of 6.1 course hours, the female students in 5.65 course hours, and the male students in 6.71 course hours. In addition to this, the data obtained showed that learning difficulties belonging to the learning groups decreased as the space below the curve of time and learning amount decreased. As a result of the study, it was recommended that it is possible to determine the closest course hours for the full learning level for each of the gains included in all levels of education and all teaching programs.

Keywords: *Learning difficulties, natural numbers, sixth grade, time*

INTRODUCTION

Many studies have been carried out within the scope of the understandings of *"how it is formed, from what they are affected, whether the concept of learning is created by one product only",* which form the legacy of an ancient culture, and they are presented with different approaches. Although the concept of learning has changed many aspects especially with today's reality and a versatile movement of change of technology and many ideas/theories have been expressed on this topic, no clear definition has been able to given for the concept of learning. Together with the alternative theories especially on the nature of learning, an important paradigm transition has been experienced in our ideas from the behaviorist towards cognitivist and structural learning theory on how learning occurs in the century in which we live (Cooper, 1993). For example, according to the behaviorist approach, learning is the accumulation of crumbles of knowledge in one sense; learning occurs when the students give proper reactions to external stimuli for each crumble of knowledge in an automatic manner (Lave & Wenger, 1991). In cognitive approach, which is another approach, it is emphasized that learning cannot be explained merely by stimulant-reaction behavior, and learning process is a mental process with cognitive and affective dimensions, and this process may be understood. According to the cognitive learning theory, the individual creates mental models about the functioning of the world in the learning process, and these models change depending on new experiences (Phillips, 1995). In this approach, the individual is considered as a learner who tries to make sense based on his/her new experiences and on existing mental models and who makes interpretations. According to the structural learning theory, on the other hand, information cannot be transferred from an external source to the individual; it is structured by the individual in an active manner. The considerations on the learner and the learning process, which are put forward by the structural theory, are clearly separated from behaviorism and cognitivism, which handle learning in an objective perspective. Objective world view is based on assumptions like there is an external reality that has been structured according to the characteristics and relations; and the external world may be known in an accurate and exact manner; the symbols are the representations of reality and are meaningful as long as they fit the external reality; the world may be defined with theoretical models; and the mind processes the symbols based on mathematics and the rules of logic like a computer (Jonassen, 1991). In this view point, it is considered that information exists independently from the learner, and is internalized when it is transferred from the external reality into the internal reality of the learner (Köseoğlu & Tümay, 2013).

One of the first descriptions of learning was made by Aristotle (BC. 384-322). According to Aristotle; we remember objects i) when they are similar, ii) when they are different from each other, iii) when they are adjacent (Hoy, 2015). However, learning with traces of the many changes is considered as a product (what is learned) or a process that expresses a product or in the overall sense (Gökalp, 2005). Learning is also considered as a change with a relatively permanent trace occurring in a behavior and a potential behavior as a product of experience (Senemoğlu, 2003). When taken as a whole, various factors such as species-specific readiness, maturity, general evoked status, anxiety, motivation, attention, past experiences, the structure of the subject matter, learner's active participation, feedback and the time devoted to learning are known to be effective on the learning (Bacanlı, 2005). In addition to mentioning the factors that can influence many learning situations such as learner, the subject matter, teaching materials, learning environment and so on, the traces of a theoretical understanding to seek an answer to the question of *"what is the influence of time on learning difficulty?",* which comprises the starting point of the study carried out can also be searched. The challenge here is to express the learning potential of students depending on time (course hours). In other words, we can say that it is an indication of their learning difficulty depending on the challenges met in learning.

We see that the targeted behaviors to be acquired by students are dealt with within a time frame both in the curricula of our country and in the international ones (Eurydice, 2009; Kelly, 2009; Ministry of National Education [MNE], 2013, NCTM, 2000; OECD, 2004). In this context; all the other factors such as the evaluation forms and criteria applied in secondary education, the organization of teaching and the methods used as well as the time (course hours) factor that students learn mathematics make an important contribution to the student achievement (Eurydice, 2011). However, due to the official course time allocated to certain classes, the right of school to allocate extra time for certain classes in many cases or the potential of a complete autonomy in overall allocation of course hours; the time that students spend on classes will not always be reflected in a real way (Eurydice, 2011). In this context, to determine the most appropriate course hours to learning objectives identified in the curriculum is critical for the learner. On this matter, the teachers' reports, the most-frequent student activities in math class and the data from Trends in International Mathematics and Science Study [TIMSS] have been reported to be benefited from in determining the course time allocated to the math subjects in international studies (Mullis, Marin & Foy, 2008).

In the literature, there are many factors affecting the success of students in mathematics such as; problem solving skills (Heppner & Lee, 2009; Koç, 2014), learning styles (Peker, 2005; Yenilmez & Çakır, 2005), attitudes and interests (Ma & Kishor, 1997; Peker & Mirasyedioğlu, 2003), self-regulation strategies (Arsal, 2009, Üredi & Üredi, 2005), spatial ability (Clements & Battista, 1992; Prugh, 2012), reasoning skills (Trybulski, 2007; Umay, 2003) self-efficacy (Hoffman & Spatariu, 2008; Yıldırım, 2011). One of the operational dimensions leading to such factors is the learning's speed dimension which comprises the belief dimension related to the rapid and gradual realization of learning. Accordingly, the learning speed induced by such factors as each learner's learning capacity in a classroom environment, cognitive/affective structure, past education/experiences and so on may vary. According to Kardash and Howell (2000), the speed of learning not only involves the features of the organization of knowledge but also the beliefs about the nature of learning. The speed of learning is also shown among the dimensions of the epistemological beliefs system, and consists of a continuum extending from the belief that learning is realized either slowly or is never realized, to the belief that learning is realized gradually and takes time (Qian & Alvermann, 1995; Schommer, 1990). We can say that this dimension, built upon whether the learning is realized rapidly or not and included in the structure of epistemological beliefs, is dependent on the time between quality of learning and the learner and the amount of learning. Because, although the learner has been attempted to be characterized by different approaches and theories, it has been witnessed that each learner has his own speed, time and style of learning (Allinson & Hayes, 1996; Coffield, Moseley, Hall & Ecclestone, 2004; Dunn, 2000). In addition; the differences in learning experiences is not related to the students' amount of learning, but rather to the individual differences in their learning styles, interests, motivations, speeds and times (Bloom, 1998; Tuğrul, 2002). Thus, the most important reason for the study conducted is to create a structure that will reveal the quantitative relation between time and learning as well as a source for the related field. In the study conducted at the sixth grade level, the case of *"solving problems with natural numbers"* was dealt with. Although a particular preference is not made while selecting topics, both the fact that it is a challenging topic for students and that the students have learned the related topic before the study have been taken into account.

When examining the literature, a large number of studies on students' problem solving skills can be found (Heppner & Lee, 2009; Kılıç, 2013; Merriënboer, 2013; Özsoy, 2005; Yenilmez & Yılmaz, 2008). For example, as a result of the study conducted by Özsoy (2005) on 107 students, a positive relationship was observed between problem solving and student achievement. In another study, Kılıç (2013) tried to determine the performances of 452 students for problems involving four operations with natural numbers. As a result of the study; it was determined that students experienced such problems, besides the required four operations, as posing problems for other operations, inability to answer, using incomplete data in problem posing, using decimals instead of natural numbers, writing exercises and problem posing for different subjects. A quantitative study conducted by Karaoğlan (2009) found a significant positive relationship between the achievement scores received by the students after the activities based on problem solving in topics of natural numbers and average math achievement scores. The challenges that 56 secondary school students faced in solving problems were investigated in a study carried out by Yeo (2009). According to the results of the study, insufficiencies in the correct use of mathematics and strategy, conversion and interpretation of the problem have been observed. Similarly, it was defined in the study of Yenilmez and Yılmaz (2008) carried out on 960 students to investigate the misconceptions in problem solving, that the maximum number of student errors was realized in the case where problems units were changed. The common point of the studies carried out is that these errors are more of a learner-centered problem such as students' problem-solving skills/competencies, misconceptions, challenges faced in solving problems, and understanding the cognitive structures developed to solve the problem. However, the fact that no theoretical study has been met on the adequacy of the designated school hours to provide problem-solving skills to students demonstrates the need for such a study. For this reason, the study carried out is believed to help fill the gap in the field. As a result, the average course period allocated to the gain of *"solving problems requiring four operations with natural numbers",* which is included in the sixth grade mathematics curriculum in our country corresponds to 2.75 course hours. How do the designated course hours for such acquisitions affect the learning amounts of students? What level of learning does the learning group or one learner reach in a course period? Moving from the questions above, the main purpose of this study is to determine the time-dependent learning difficulties of *"solving problems that require making four operations with natural numbers"* of the sixth grade students.

METHODOLOGY

Research Model

The general and individual screening models were used in the study. General screening models are screening arrangements conducted on the whole universe or a group or sample taken from it with the aim of reaching a general conclusion about the universe consisting of a number of elements (Karasar, 2009). Singular scans can also be done with general scanning models. Besides the detection of instant cases, temporal developments and changes can also be determined with singular screening models. In this model, the formation of variables can be determined in individual, typical or quantitative terms (Karasar, 2009).

Study Group

The study group consists of a total of 140, 6th grade students, including 69 girls (49.3%) and 71 boys (50.7%), who attend a public secondary school in the province of İzmir, during the 2015-2016 academic year. There are 12 branches in the sixth grade in the school, where students with a middle socio-economic level receive education. The measurement tool was applied to 5 branches selected by random sampling method. The study was carried out after the learning field of *"numbers and operations*" was taught. The procedures to be performed on the study group are as follows:

- ✓ Determination of learning difficulty from the time-dependent learning amount of the learning group (140 students),
- ✓ Determination of learning difficulty from the time-dependent learning amount of female (n=69) and male (n=71) students.

While forming the student ranking; the scores that the students took from the measurement tool were lined up from high to low by giving them a participant rank. For example, one of the highest scoring students was specified as "Participant 1" [P1] and listed in order of scores.

Table 1. The scores that the students got from the measuring tool and their genders

Rank	Scores	Gender	Rank	Scores	Gender	Rank	Scores	Gender	Rank	Scores	Gender
P1	47	Male	K36	32	Male	P71	23	Male	P106	11	Female
P2	47	Female	P37	32	Male	P72	22	Male	P107	11	Female
P3	46	Female	P38	32	Female	P73	22	Female	P108	10	Male
P4	46	Female	P39	31	Female	P74	22	Male	P109	10	Male
P5	45	Female	P40	30	Female	P75	21	Female	P110	10	Female
P6	44	Male	P41	30	Female	P76	21	Male	P111	10	Female
P7	43	Male	P42	29	Female	P77	20	Female	P112	10	Female
P8	43	Female	P43	29	Female	P78	20	Female	P113	9	Female
P9	42	Male	P44	29	Female	P79	20	Female	P114	9	Male
P10	42	Female	P45	28	Male	P80	19	Female	P115	9	Female
P11	41	Male	P46	28	Female	P81	19	Female	P116	9	Female
P12	41	Male	P47	28	Female	P82	19	Male	P117	8	Female
P13	40	Female	P48	27	Male	P83	19	Female	P118	8	Male
P14	40	Female	P49	27	Female	P84	19	Male	P119	8	Male
P15	40	Female	P50	27	Female	P85	18	Male	P120	8	Female
P16	40	Male	P51	27	Female	P86	18	Female	P121	8	Female
P17	39	Female	P52	27	Male	P87	18	Female	P122	8	Male
P18	39	Male	P53	26	Male	P88	18	Female	P123	7	Male
P19	39	Male	P54	26	Male	P89	18	Male	P124	6	Male
P20	38	Female	P55	26	Female	P90	17	Male	P125	6	Male
P21	37	Female	P56	26	Male	P91	17	Female	P126	5	Male
P22	37	Female	P57	26	Male	P92	16	Male	P127	5	Male
P23	36	Male	P58	26	Male	P93	16	Female	P128	5	Male

Rank	Scores	Gender	Rank	Scores	Gender	Rank	Scores	Gender	Rank	Scores	Gender
P24	36	Male	P59	25	Male	P94	16	Female	P129	4	Male
P25	36	Female	P60	25	Female	P95	15	Female	P130	4	Male
P26	36	Male	P61	25	Female	P96	15	Male	P131	4	Male
P27	35	Male	P62	25	Male	P97	15	Female	P132	3	Male
P28	34	Female	P63	24	Male	P98	15	Male	P133	3	Male
P29	34	Male	P64	24	Male	P99	15	Female	P134	3	Male
P30	34	Female	P65	24	Female	P100	14	Male	P135	3	Male
P31	34	Male	P66	24	Male	P101	14	Female	P136	3	Male
P32	33	Female	P67	24	Male	P102	14	Male	P137	3	Male
P33	33	Female	P68	24	Male	P103	12	Female	P138	3	Male
P34	33	Female	P69	23	Female	P104	12	Male	P139	2	Male
P35	32	Female	P70	23	Female	P105	11	Female	P140	1	Male

Data Collection Tool

The data collection tool consists of the literature, teachers and the problems including the unit of *"operations with natural numbers"* prepared based on the secondary school sixth-grade Math textbook. The secondary school sixth-grade math textbook taught in the academic year of 2015-2016 and accepted by the Board of Education was used in the preparation of questions (Bagci, 2015). The expert opinions were referred to for the questions. Whether the problems prepared are suitable for the measuring tool, and whether they represent the area to be measured is determined by the expert opinion (Karasar, 2009). Firstly, candidate problems were prepared in accordance with the objective, content and analysis of the measuring tool by a group of experts, and then whether the problems created represented these objectives and content was discussed. After the necessary studies were conducted, the essential corrections and adjustments were made in line with the recommendations of three math teachers and three field trainers. Thus, the language, content, relevance and scope of validity of the question were provided. By applying the questions belonging to the first form, which took their final shape, to 18 students, the pilot study was conducted. Thanks to the pilot study, the points that students had difficulty understanding were identified and the necessary corrections were made. For example, one of the sentences was rephrased since it caused misunderstandings of the students, and another one was excluded from the measurement tool for its level of difficulty.

The internal consistency was examined for the fitness of the scale to structural validity. Upon the analysis, no items with low item-total correlation value were observed among the 12 items in the scale. The Kaiser-Meyer Olkin (KMO) and Barlett Sphericity Tests were applied in order to determine whether the 12-item scale fit the factor analysis or not. The KMO value, which is used in determining whether the data and the sampling size fit the analysis and was adequate or not, was found to be .94. In addition, the Barlett Sphericity Test, which is applied to check whether the data come from normal distribution or not, was applied; and it was found to be meaningful (x^2=1007.2, $p<.01$). It is necessary that the KMO test measurement result is .60 and over, and the Barlet Sphericity test result is statistically significant (Jeong, 2004). Since the values that were obtained as a result of the analyses covered these basic assumptions at a good level, it was decided that factor analysis could be applied. The components matrix converted with the Varimax method, which was obtained as a result of the factor analysis, is shown in Table 2, and the eigenvalue graphics is given in Figure 1. In order to ensure that factor variances have the highest value with fewer variables, the Varimax method, which is among the vertical conversion methods, has been preferred. According to the analysis results, the measurement tool explained 54.9% of the total variance under one single factor.

Table 2. Exploratory factor analysis of the scale

Item	The common factor variance	Load factor value
1	.554	.738
2	.531	.729
3	.511	.715
4	.454	.674
5	.508	.713
6	.547	.740
7	.686	.828
8	.652	.807
9	.547	.739
10	.596	.772
11	.567	.753
12	.455	.674
The total of eigenvalue=6.597		
The total of explained variance=54.976		

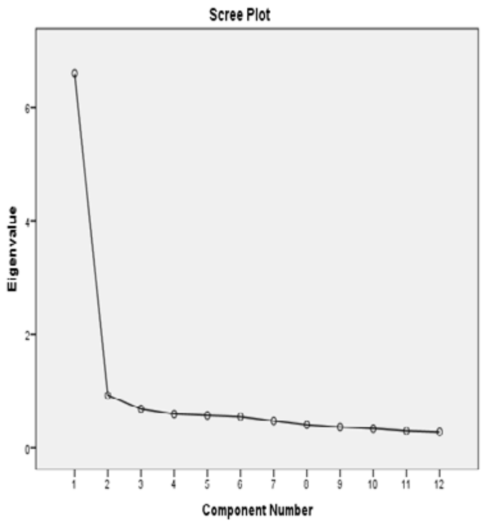


Figure 1. Scree Plot

In order to test the construct validity of the data collection tool developed, the Confirmatory Factor Analysis (CFA) was performed [x^2/sd=1.73; CFI=0.95; RMSEA=0.07; IFI=0.96; GFI=0.90; AGFI=0.86; NFI=0.91; PNFI=0.74]. The Cronbach Alpha reliability coefficient of the final 12-item measuring tool was calculated as 0.92 (n=157).

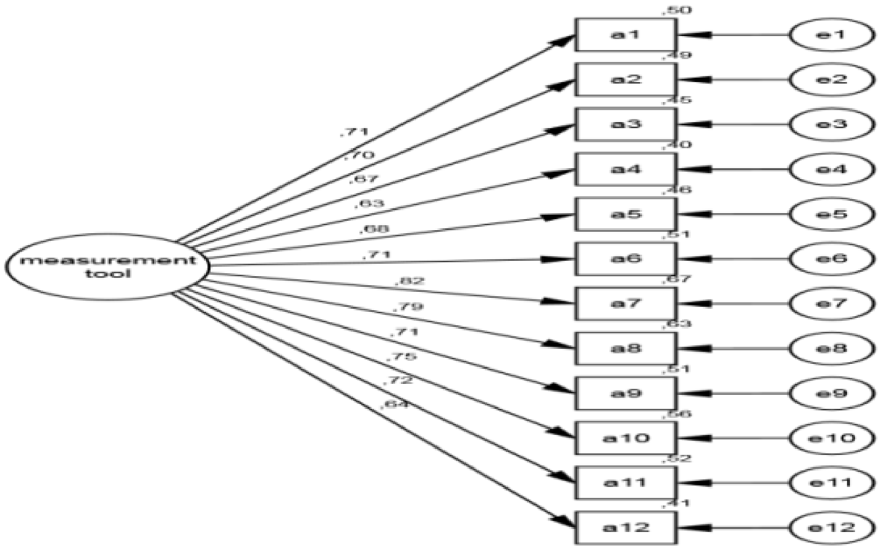


Figure 2. Confirmatory factor analysis chart pattern

The questions prepared in order to determine the quality of learning were prepared to reveal the characteristic feature of the related gain, and following the necessary corrections, the measurement tool became ready for application. The maximum score that can be taken from the measuring tool was set as 48 and the minimum score as 0. The allocated time for the 4 acquisitions whose lower learning areas are numbers and operations in the curriculum is defined approximately as 11 course hours (MNE, 2013). In this case, the time allocated for each acquisition, including the acquisition featured in our study consists of 2.75 course hours. The sample problems prepared in accordance with the acquisition and the acquisition they belong to are presented in the table below.

Table 3. Sample problems and acquisitions

The Content Of The Problem	Acquisition
The price of a pair of trousers sold in a store is 45 TL less than the price of a jacket and 15 TL more than the price of a shirt. The price of the jacket is 100 TL; so, how much does a person who buys 3 jackets, 3 pairs of trousers and 3 shirts have to pay?	Operations in Natural Numbers: The student solves problems that require four operations with natural numbers.
1000 people visited The Hagia Sophia in January, 1200 in February, and in March, 200 people fewer than the total number of visitors in January and February went there. The entrance fee for each visitor is 3 TL; so, how much revenue has been achieved from all the visitors coming to the museum in January, February and March?	
The daily fee of a hotel room is 80 TL per person and 0-6 year-olds are accepted free of charge, and the fee for 7-12 year-olds is half of adult price. The Kaya Family, of 5 persons, will be staying at the hotel for a 5-day vacation. The Kaya family has 3 children, aged 4, 7 and 15; so, how much does this family have to pay for a 5-day vacation?	

Data Analysis

The reliability of the measurement tool and the explanatory factor analysis were performed with SPSS 20.0; and the confirmatory factor analysis was performed with AMOS 24.0 package program. The Graph Program was made use of in drawing the graphics. The progressive scores scale in Table 3 below, which was developed by Marzano (2000), to analyze the 12 open-ended questions, which cover the acquisition of solving problems that require four operations with natural numbers that belongs to the learning area of numbers and operations and the lower learning area of operations with natural numbers, which are in the Curriculum of Secondary School Mathematics Course was used (Grades 5, 6, 7 and 8) (MNE, 2013). It is important for the students to give an explanation in this scoring scale. In this context, in order to establish a more robust assessment, the students were asked to give answers in a more detailed manner during the implementation of the scale.

Table 4. Progressive scores scale

Student Behaviors to be Observed (Criteria)	Scores
If the student selects the most effective solution to overcome an obstacle or difficulty and explains why it is the most effective one among the possible solutions,	4
If the student selects the most effective solution to overcome an obstacle or difficulty and cannot fully explain why it is the most effective one among the possible solutions,	3
If the students selects the right solution to overcome an obstacle or difficulty, but this solution is not the most effective one, and the answer he gives shows the solution process even if partly,	2
The solution he selects is not able to overcome the obstacle or challenge,	1
If the student withholds judgment,	0

To determine the amount of time-dependent learning the formula that specifies the model of learning a task in psychology was utilized (Nagle, Saff & Snider, 2013):

- n= the qualification of the learning [the number of questions that characterize the subject learned]
- p=the qualification of the person/group [acquisition/success derived from the acquisitions]
- c= the arbitrary constant which depending on personal learning
- y= the amount of learning
- t= time [learning time of the acquisition]

*The Formula Modeling the Learning: $$\frac{dy/dt}{(y-y^2)^{\frac{3}{2}}} = \frac{2p}{\sqrt{n}} \quad \Rightarrow \quad \frac{4y-2}{\sqrt{y-y^2}} = \frac{2p}{\sqrt{n}} \cdot t + c$$

**Using the formula: Firstly, the measurement tool was created according to the acquisition which characterizes the related subject in the curriculum. In order to develop the measurement tool, in addition to the relevant literature, the opinions of experts and course teachers were taken and the number of open-ended questions was determined in accordance with the acquisitions. The determined he number of questions was recognized as the quality of learning. The scores obtained from the measurement tool were taken into account to determine the quality of each learner or group. In the next step, the constant values changing based on the group or individual learning were found. Finally, the time-dependent parameter values were examined based on an amount of learning at a certain level.*

RESULTS

In this section; the findings obtained from the analysis on the amount of learning of the male and female students who are located at high, medium and lower learning levels and the comments on these findings were given place to.

The Time-Dependent Learning Difficulty of the Learning Group

Below are the calculations made to determine the learning difficulties of learning group. The learning group consists of a total of 140 students. The quality of the learning group, the quality of the learning, the amount of learning, time allocated to learning and the fixed values changing according to these components are as follows:

- n= 12 [number of questions that reflect the characteristic of the acquisition]
- p= 3136/140=22,4 [the average score obtained from the acquisition]
- t= 1,25 [learning time allocated to the acquisition]
- c= the parameter
- y= 1/2 [variable]

Below are the calculations made to determine the amount of time-dependent learning.

y=1/2 the amount of half learning

$$\frac{dy/dt}{(y-y^2)^{\frac{3}{2}}}=\frac{2p}{\sqrt{n}} \Rightarrow \frac{4y-2}{\sqrt{y-y^2}}=\frac{2p}{\sqrt{n}}\cdot t+c \Rightarrow \frac{4.\frac{1}{2}-2}{\sqrt{\frac{1}{2}-\left(\frac{1}{2}\right)^2}}=\frac{2.22,4}{\sqrt{12}}.(1,25)+c \Rightarrow c\cong -16,18$$

$$\frac{4y-2}{\sqrt{y-y^2}}+16,18=\frac{2.22,4}{\sqrt{12}}.t \Rightarrow \sqrt{12}.(\frac{4y-2}{\sqrt{y-y^2}}+16,18)=44,8.t$$

$$\frac{\sqrt{12}.(4y-2)}{44,8.\sqrt{y-y^2}}+\frac{\sqrt{12}.16,18}{44,8}=t$$

[The equation for the relationship between the time and the amount of learning of the learning group]

In the light of the data obtained from the amount of half learning, the graphics related to the amount of time dependent learning and the learning difficulties of the learning group are listed below.

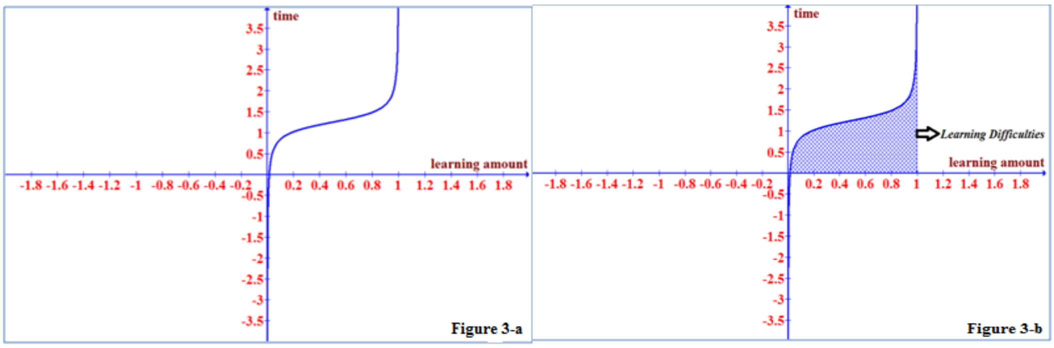


Figure 3-a, b. The graphics related to the amount of time dependent learning and the learning difficulties of the learning group

Table 5: Parameter values between the amount of learning of the learning group and time

Parameter values between the amount of learning and time									
The amount of learning	0.038	0.189	0.500	0.814	0.963	0.985	0.989*	0.994	0.999
Time	0.5	1.0	1.25	1.5	2.0	2.5	2.75	3.2	6.1

(*Lower limit for amount of full learning level)

Examining the values in Figure 3-a and Table 5; it is seen that there is a non-linear correlation between time and amount of learning. The learning group reached the learning amount of 0.038 in course period of 0.5, the learning amount of 0.189 in a course period of 1.0; the learning amount of 0.500 in a course period of 1.25; the learning amount of 0.814 in a course period of 1.5; the learning amount of 0.963 in a course period of 2.0; the learning amount of 0.985 in a course period of 2.5; the learning amount of 0.989 in a course period of 2.75; the learning amount of 0.994 in a course period of 3.2; and the learning amount of 0.999, which is the closest value to the complete learning level, in a course period of 6.1. Considering that the average of 2.75 course hours allocated to the related acquisition in the curriculum, it is observed that an amount of 0.011 is ignored, which is required for the learning group to reach the complete learning level. The result obtained indicates that this duration should be reviewed again. The reason for this case is that an additional course hour of 3.35 is needed to reach the learning level of 0.999, which is the closes value to the complete learning level. This period is more than even the course hour of 2.75, which is allotted for acquisition. According to these results, it can be said that the time needed for the acquisition increases significantly as getting closer to the complete learning level. In addition, the curve's movement in the negative areas indicates the traces of the past learning experiences of the learning group. When Figure 3-b is examined, it is seen that as the students get closer to the complete learning level, the number of course hours needed and the area under the curve increase. Also, as the students get closer to the complete learning level, the change in the time elapsed becomes clearer. In this case, the fact that the time needed for a learning amount of 0.149 (0.963-0.814) is equal to the time needed for a learning amount of 0.022 (0.985-0.963) can be given as an example.

Multiplication of time in units by the amount of learning, in other words, the area below the curve gives the potential situation, that is, the learning difficulties of the learning group. The following are the figures showing the changes of the learning difficulties of the learning group in the range of learning amounts.

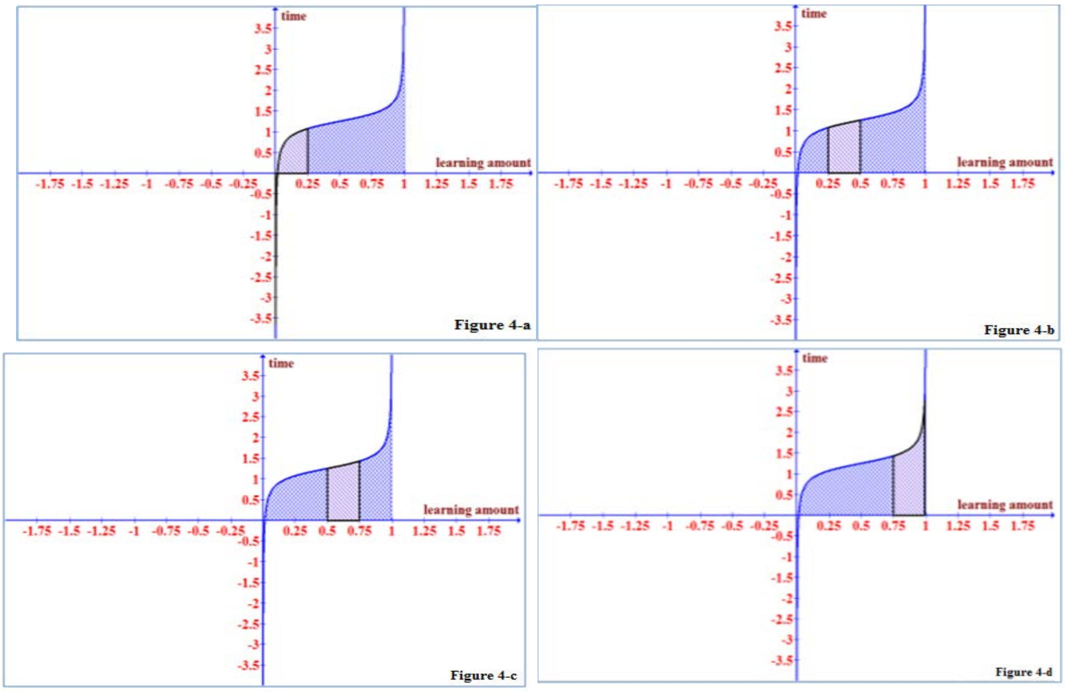


Figure 4-a, b, c, d: The graphics for learning difficulties of the learning group

Table 6: Parameter values of the learning difficulties occurring between the time and amount of learning

Parameter values belonging to the area below the curve formed between the time and amount of learning				
The range of learning amount	0.001-0.250	0.250-0.500	0.500-0.750	0.750-0.999
Learning difficulties	0.187	0.292	0.333	0.435

An analysis of the values given in Table 6 indicates a decrease in the amount of learning difficulties of the learning group when the area under the curve decreases (Figure 4-a, b, c, d). According to the table, when the range of learning amount becomes 0.001-0.250, the learning difficulty becomes 0.187; when the range becomes 0.250-0.500, the learning difficulty becomes 0.292; when the range becomes 0.500-0.750, the learning difficulty becomes 0.333; and when the range becomes 0.750-0.999, the learning difficulty becomes 0.435. This situation shows us that new learnings slow down and learning difficulties increase as the course hour's increase, that is, as learning is achieved. When the area under the curve expands, an increase in the amount of learning difficulties takes place. As an indicator of this case, we can show the changes in the learning difficulty in the range of 0.001-0.250 and in the learning difficulty in the range of 0.250-0.500. In short, as the learning difficulties increase, the amount of time needed for complete learning also increases.

The Time-Dependent Learning of Female Students

Below are the calculations made to determine the amount of time-dependent learning of female students. The female learning group consists of a total of 69 students. The quality of the female learning group, the quality of the learning, the amount of learning, time allocated to learning and the fixed values changing according to these components are as follows:

- n= 12 [number of questions that reflect the characteristic of the acquisition]
- p= 1715/69=24,85 [the average score obtained from the acquisition]
- t= 1,25 [learning time allocated to the acquisition]
- c= the parameter
- y= 1/2 [variable]

Below are the calculations made to determine the amount of time-dependent learning:

y=1/2 the amount of half learning

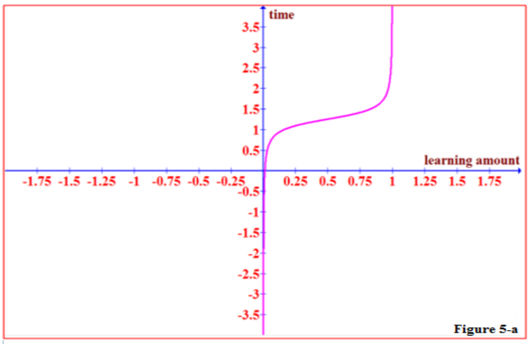
$$\frac{dy/dt}{(y-y^2)^{\frac{3}{2}}}=\frac{2p}{\sqrt{n}} \Rightarrow \frac{4y-2}{\sqrt{y-y^2}}=\frac{2p}{\sqrt{n}}\cdot t+c \Rightarrow \frac{4.\frac{1}{2}-2}{\sqrt{\frac{1}{2}-\left(\frac{1}{2}\right)^2}}=\frac{2.24{,}85}{\sqrt{12}}.(1{,}25)+c \Rightarrow c\cong -17{,}95$$

$$\frac{4y-2}{\sqrt{y-y^2}}+17{,}95=\frac{2.24{,}85}{\sqrt{12}}.t \Rightarrow \sqrt{12}.(\frac{4y-2}{\sqrt{y-y^2}}+17{,}95)=49{,}7.t$$

$$\frac{\sqrt{12}.(4y-2)}{49{,}7.\sqrt{y-y^2}}+\frac{\sqrt{12}.17{,}95}{49{,}7}=t$$

[The equation for the relationship between the time and the amount of learning of the female students]

In the light of the data obtained from the amount of half learning, the graphics related to the amount of time dependent learning and the learning difficulties of the female learning group are listed below.



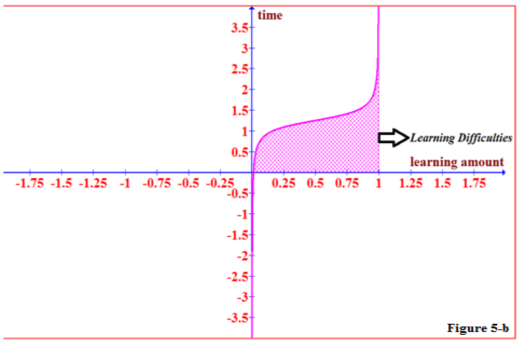


Figure 5-a, b: The graphics related to the amount of time dependent learning and the learning difficulties of the female learning group

Table 7: Parameter values between the amount of learning of the female learning group and time

Parameter values between the amount of learning and time									
The amount of learning	0.032	0.166	0.500	0.834	0.969	0.988	0.989*	0.994	0.999
Time	0.5	1.0	1.25	1.5	2.0	2.5	2.55	3.0	5.65

(*Lower limit for amount of full learning level)

According to the values in Figure 5-a and Table 7; the female learning group reached the learning amount of 0.032 in course period of 0.5, the learning amount of 0.166 in a course period of 1.0; the learning amount of 0.500 in a course period of 1.25; the learning amount of 0.834 in a course period of 1.5; the learning amount of 0.969 in a course period of 2.0; the learning amount of 0.988 in a course period of 2.5; the learning amount of 0.989, which is the lower limit of complete learning, in a course period of 2.55; the learning amount of 0.994 in a course period of 3.0; and the learning amount of 0.999, which is closest value to the full learning level, in a course period of 5.65. Considering the level of 0.989, which is defined as lower limit for complete learning in the study, and the time allotted for this acquisition in the curriculum; the time required for the female students to reach the complete learning seems to be lower than 2.75 course hours. In addition, as can be understood from the curve in Figure 5-b, the time required for the female students to reach the desired learning level extends to the infinity, and is located in the line of 5.65 course hours at the level of 0.999, which is the closest value to the complete learning level. Similar to the learning group, the fact that the graph curve belonging to the learning amount of the female students cuts the axis of learning amount in negative value ranges indicates that this group had a certain amount of learning at the beginning. As the students get closer to the complete learning level, the change in the time elapsed becomes clearer. In this case, the fact that the time needed for a learning amount of 0.135 (0.969-0.834) is equal to the time needed for a learning amount of 0.019 (0.988-0.969) can be given as an example. The following are the figures showing the changes of the learning difficulties of the female learning group in the range of learning amounts.

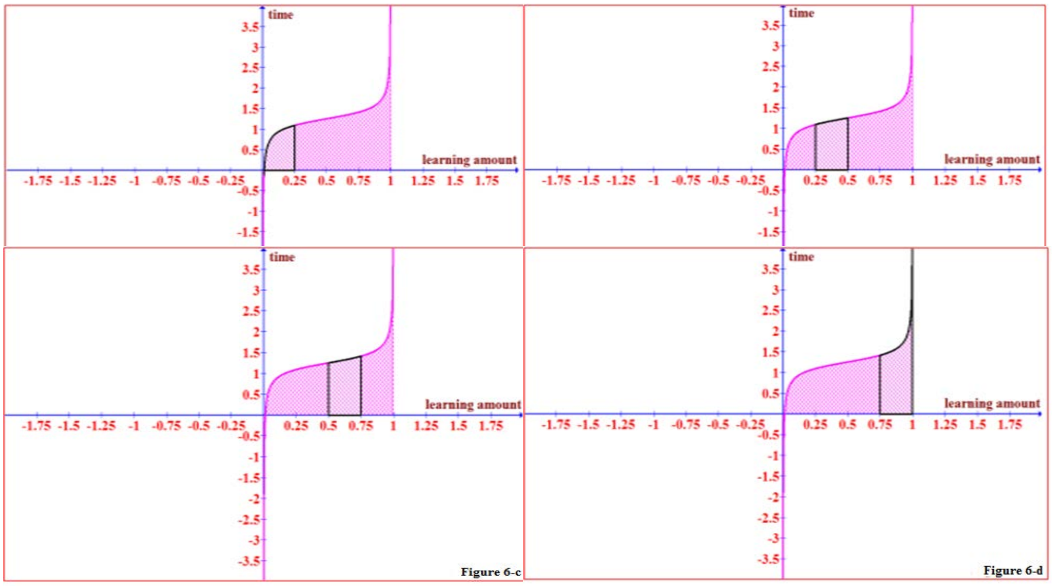


Figure 6-a, b, c, d: The graphs for learning difficulties of the female learning group

Table 8: Parameter values belonging to the learning difficulties occurring between the time and amount of learning

Parameter values belonging to the area below the curve formed between the time and amount of learning				
The range of learning amount	0.001-0.250	0.250-0.500	0.500-0.750	0.750-0.999
Learning difficulties	0.199	0.294	0.331	0.423

An analysis of the values given in Table 8 indicates a decrease in the amount of learning difficulties of the female learning group when the area under the curve decreases (Figure 6-a, b, c, d). According to the table, when the range of learning amount becomes 0.001-0.250, the learning difficulty becomes 0.199; when the range becomes 0.250-0.500, the learning difficulty becomes 0.294; when the range becomes 0.500-0.750, the learning difficulty becomes 0.331; and when the range becomes 0.750-0.999, the learning difficulty becomes 0.423. This situation shows us that new learnings slow down and learning difficulties increase as the course hour's increase, that is, as learning is achieved. When the area under the curve expands, an increase in the amount of learning difficulties takes place. As the reason for this case, we can show that the learning difficulty is 0.199 in the range of 0.001-0.250 while the learning difficulty in the range of 0.250-0.500 is 0.294.

The Learning Difficulty of Male Students

Below are the calculations made to determine the learning difficulties of the male learning group. The male learning group consists of a total of 71 students. The quality of the male learning group, the quality of the learning, the amount of learning, time allocated to learning and the fixed values changing according to these components are as follows:

- n= 12 [number of questions that reflect the characteristic of the acquisition]
- p= 1421/71=20,01 [the average score obtained from the acquisition]
- t= 1,25 [learning time allocated to the acquisition]
- c= the parameter
- y= 1/2 [variable]

Below are the calculations made to determine the amount of time-dependent learning:

y=1/2 the amount of half learning

$$\frac{dy/dt}{(y-y^2)^{\frac{3}{2}}} = \frac{2p}{\sqrt{n}} \Rightarrow \frac{4y-2}{\sqrt{y-y^2}} = \frac{2p}{\sqrt{n}}\cdot t + c \Rightarrow \frac{4.\frac{1}{2}-2}{\sqrt{\frac{1}{2}-\left(\frac{1}{2}\right)^2}} = \frac{2.20{,}01}{\sqrt{12}}.(1{,}25)+c \Rightarrow c \cong -14{,}45$$

$$\frac{4y-2}{\sqrt{y-y^2}} + 14{,}45 = \frac{2.20{,}01}{\sqrt{12}}.t \Rightarrow \sqrt{12}.(\frac{4y-2}{\sqrt{y-y^2}} + 14{,}45) = 40{,}02.t$$

$$\frac{\sqrt{12}.(4y-2)}{40{,}02.\sqrt{y-y^2}} + \frac{\sqrt{12}.14{,}45}{40{,}02} = t$$

[The equation for the relationship between the time and the amount of learning of the male students]

In the light of the data obtained from the amount of half learning, the graphics related to the amount of time dependent learning and the learning difficulties of the learning group are listed below.

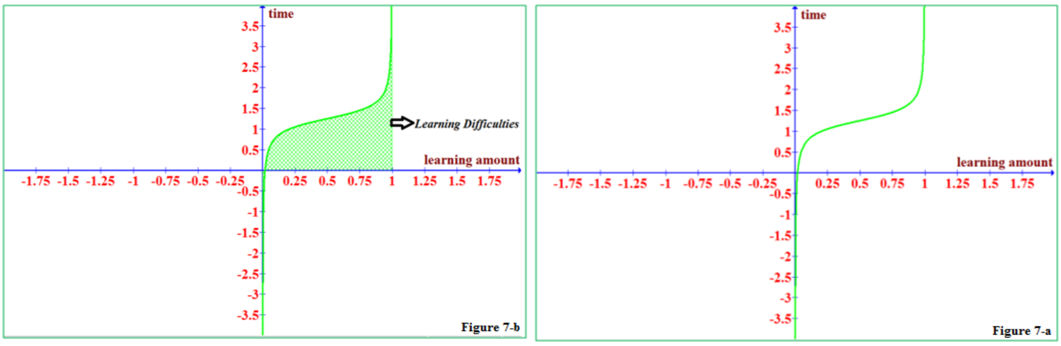


Figure 7-a, b: The graphics belonging to the amount of learning and the learning difficulties of the male learning group

Table 9: Parameter values between the amount of learning of the male learning group and time

Parameter values between the amount of learning and time									
The amount of learning	0.046	0.210	0.500	0.793	0.954	0.982	0.989*	0.994	0.999
Time	0.5	1.0	1.25	1.5	2.0	2.5	2.87	3.46	6.71

(*Lower limit for amount of full learning level)

According to the parameter values in Figure 7-a and Table 9; it is seen that the learning amount of 0.210 was reached in 1.0 course hours, and the half learning amount in 1.25, however, the time need for learning is 1.5 when the learning amount is 0.793; 2 in 0.954; 2.5 in 982; 2.87 in 0.989, 3.46 in 0.994; and 6.71 in 0.999. According to these results, it can be said that the increase in learning amount is at a low level; however, the course hours needed for learning has increased as getting closer to the complete learning level of 1.0. Considering the level of 0.989, which is defined as lower level of complete learning in the study, and the time allotted for this acquisition in the curriculum; the time required for the male students to reach the complete learning seems to be higher than 2.75 course hours. As can be seen in the curve of Figure 7-a, the time required for the male students to reach the desired learning level extends to the infinity, and is located in the line of 6.71 course hours at the level of 0.999, which is the closest value to the complete learning level. Furthermore, the fact that the graph curve belonging to the learning amount of the male students given in Figure 7-a cuts the axis of learning amount indicates that this group had a certain amount of learning at the beginning. Examining the values in Figure 7-b; it is seen that there is a non-linear correlation between time and amount of learning. Time and the learning amount, that is, the area below the curve gives the learning difficulties of the male students. When the area under the curve decreases, an increase occurs in the learning difficulties of male students, and when it increases, an increase occurs. The fact that the time needed for a learning amount of 0.161 (0.954-0.793) is equal to the time needed for a learning amount of 0.028 (0.982-0.954) can be given as an example for this case The following are the figures showing the changes of the learning difficulties of the male learning group in the range of learning amounts.

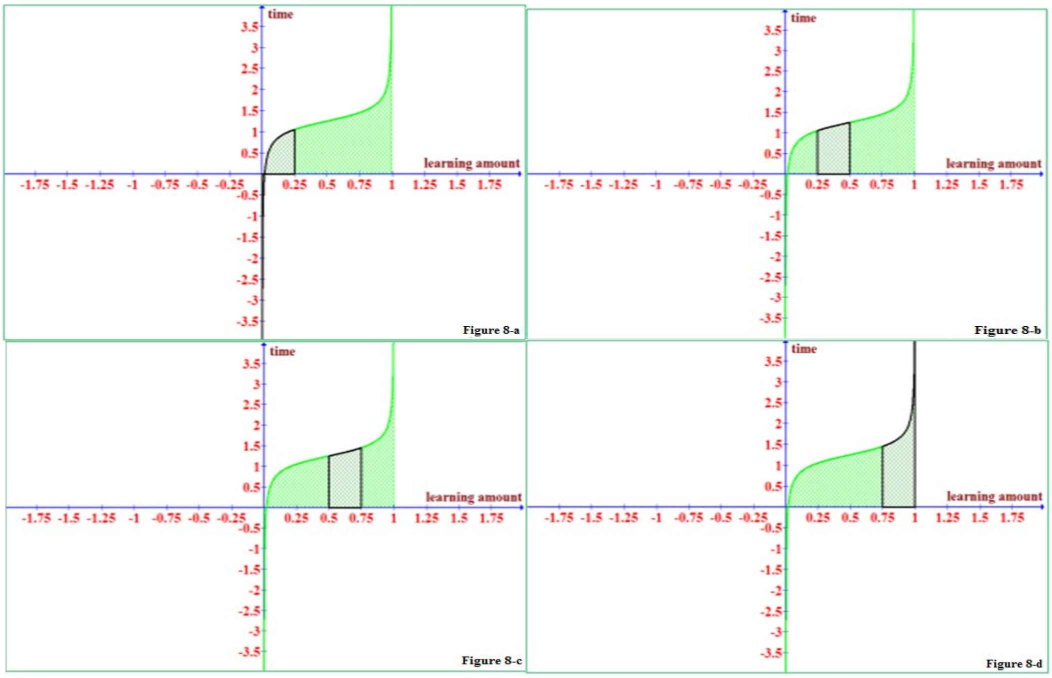


Figure 8-a, b, c, d: The graphs for learning difficulties of the male learning group

Table 10: Parameter values belonging to the learning difficulties occurring between the time and amount of learning

Parameter values belonging to the area below the curve formed between the time and amount of learning				
The range of learning amount	0.001-0.250	0.250-0.500	0.500-0.750	0.750-0.999
Learning difficulties	0.172	0.289	0.335	0.450

An analysis of the values given in Table 10 indicates a decrease in the amount of learning difficulties of the male learning group when the area under the curve decreases (Figure 8-a, b, c, d). According to the table, when the range of learning amount becomes 0.001-0.250, the learning difficulty becomes 0.172; when the range becomes 0.250-0.500, the learning difficulty becomes 0.289; when the range becomes 0.500-0.750, the learning difficulty becomes 0.335; and when the range becomes 0.750-0.999, the learning difficulty becomes 0.450. This situation shows us that new learnings slow down and learning difficulties increase as the course hour’s increase, that is, as learning is achieved. When the area under the curve increases, an increase occurs in the amount of learning difficulties. As the reason for this case, we can show that the learning difficulty is 0.172 in the range of 0.001-0.250, while the learning difficulty is 0.289 in the range of 0.250-0.500.

DISCUSSION AND CONCLUSION

In this section, the findings obtained from the study results that attempts to determine the amount of time-dependent learning amounts of the male and female students in a learning group consisting of a total 140 students including 71 male and 69 female students, for whom the acquisition of "solving problems that require four operations with natural numbers" have been addressed.

The time period allotted for the acquisition of solving problems that require four operations with natural numbers, which belongs to the learning area of numbers and operations and the lower learning area of operations with numbers, which are in the Curriculum of Secondary School Mathematics Course was determined to be 2.75 course hours on average (MNE, 2013). A total of 140 students, whom we described as the learning group, reached the learning amount of 0.989 in a period of 2.75 course hours for this acquisition. The obtained amount was determined as the lower limit of the learning amount for both the learning group, and the male and female learning groups in order to make the results more understandable. In this context, the data obtained from the learning group show that the students fell behind the complete learning level by 0.011 points. Despite this small deviation in the learning amount, a period of 3.35 course hours is needed for the closest value to the complete learning level. This time period corresponds to 134 minutes considering the course time of 40 minutes which is specified in Article 4 of the Ministry of Education Secondary Education Regulations published on the Official Gazette dated 2014 and issued 29118. Besides this, it has been concluded that the increase in the time of course hours needed also goes up due to a small increase in the amount of learning, as students come closer to the complete learning level. The fact that the additional course hours needed for the learning amount belonging to the learning group went from 0.814 to 0.963 and from 0.963 to 0.985 are the same can be shown as the strongest evidence for this situation.

Considering the relationship between the amount of learning and parameter values; it is seen that the female students reach the lower limit of complete learning in 2.55 course hours, while the male students reach this limit in 2.87 course hours. The reason for the change in the course hours of both male and female students can be due to the fact that the average point that the learning group obtained from the acquisition was 22.4, while this average was 24.85 in girls and 20.1 in boys. As can be understood from these results; depending on the increase in the quality of learning, an increase occurs in the time needed for complete learning. The learning amount of 0.999, which is the closest value to the complete learning level, was reached by the learning group in a period of 6.1 course hours, in 5.65 course hours by the female students, and in 6.71 course hours by the male students. The obtained results reveal the importance of the area below the non-linear correlation between time and the amount of learning, that is, the learning difficulties specifying the potential learning situations that the students have. We can say that not only the learning group but also the female and male learning groups have lower levels of learning difficulty as the area below the curve narrows. While the learning difficulty of the learning groups is 0.187 in the range of 0001-0.500, the result rises to 0.199 in the female learning group, but, falls to 0.172 in the male learning group. While the learning difficulty of the learning groups is 0.292 in the range of 0.250-0.500, this value is 0.294 in the female learning group and 0.289 in the male learning group. Examining the learning amount range of 0.500-0.750, we see that the learning difficulty is 0.333 in the learning group, 0.331 in the female learning group and 0.335 in the male learning group. In the learning amount range of 0.750-0.999, which is the closes range to the complete learning level, it has been concluded that the learning difficulty is 0.435 in the learning group, 0.423 in the female learning group and 0.450 in the male learning group. In the light of the data obtained, when the amount of learning is fixed and the allotted time for learning is decreased, we can say that students experience fewer learning difficulties.

We can claim that efficient transformation of the curriculum aims into classroom practices depends on many elements as well as on the determination of the class hours that are suitable and efficient for new acquisitions. As a matter of fact, the class hours proposed for teaching mathematics at schools is considered as an important property that helps to explain the importance of a subject in comparison with another subject. Especially, one of the most important factors in creating a learner-focused learning environment is the determination of suitable class durations. In this context, the duration of the students in which they learn mathematics (the class hour factor) contributes to the student success as well as to the evaluation forms and criteria applied in secondary education (Eurydice, 2011; NCTM, 2000; Özer & Anıl, 2011). In OECD (2004) report, it was stated that the suitability of class durations were in positive relations with students success. The findings obtained show that the basic problems and missing points like the mistakes in using the accurate mathematical strategy and making sense of the problems (Yeo, 2009), and other problems students face when they are solving problems that require four operations with natural numbers; being not able to establish problems for the processes, being not able to answer, using missing data, and using decimal numbers instead of natural numbers (Kılıç, 2013) may stem from suitable class hours.

The studies conducted in the literature being learner-focused like problem-solving proficiencies, misconceptions, difficulties in solving problems, and understanding cognitive structures that are developed to solve the problems support this situation (Yenilmez & Yılmaz, 2008).The aims, contents and the expected learning outcomes of today's mathematics education are generally defined in the curriculum. In this context, one of the most important contributions of this study to the literature is that it presents a model that is capable of determining the realization rate of the mathematical concept developments of the students within certain class hours. In many countries, although the class hours assigned for acquisitions differ, the class hours needed for a complete learning level may be computed. In addition, the developed model may help to create a sustainable education program and test the functionality.

Thanks to the study conducted, even though the time required for complete learning extends to infinity; considering the closest amount to the complete learning level, it is possible to determine what time range the course hours needed may be located in. In this context, the closest time of course hours to the complete learning level for each acquisition included in the curriculum can be obtained. Additionally, the scope of the study can be extended to various dimensions such as how soon the acquisition will be achieved for each student, including the students for whom an individualized curriculum is applied; the amount of learning in a specific time period; the course hours needed for future learnings. Besides this, the above-mentioned situations should be judged within their own limitations. For example, the study was intended for only one acquisition [solving problems that require four operations with natural numbers] at sixth grade level. The scope of the subject can be extended with different or more acquisitions. The average course hours of acquisitions in the curriculum were also taken into account. Therefore, the duration of the lessons that can be allocated to acquisitions may vary. However, this difference is not capable of affecting the structure of the study. The duration needed for the learner to reach the complete learning level can be easily determined regardless of the course hours specified for the acquisition. Furthermore, the most important contribution of the study to the field is that it can be applied at all levels of education, including primary and secondary education levels. In this way, decisions can be made by conducting studies on a large sample group to determine the appropriate course hours for the acquisitions in the preparation of the curriculum content of all educational levels.

Notes: Some parts of this study was presented as an oral presentation in the International Conference on Education in Mathematics, Science & Technology which was held on the date May 19-22, 2016 in Bodrum-Turkey.

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