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The Relationship between the Amount of Learning and Time (The Example of Equations)

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Abstract: The main purpose of this study is to determine the amount of time-dependent learning of "solving problems that require establishing of single variable equations of the first order" of the seventh grade students. The study, adopting the screening model, consisted of a total of 84 students, including 42 female and 42 male students at the seventh grade. Data was collected using an assessment tool consisting of 10 open-ended questions. The findings show that the learning group of 84 students were behind the value closest to the full learning level by a score of 0.013. While the female students reached the lower limit of 0.987 specified for the full learning level in a period of 3.2 course hours, the male students reached this limit in 4.0 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 9.7 course hours, the female students in 8.5 course hours, and the male students in 11.3 course hours. In addition to this, the data obtained showed that learning difficulties among 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 periods for the full learning level for each of the gains found in all levels of education and all teaching programmes, which define certain learning outcomes within a certain time.

Keywords: *Amount of learning, time, equations, seventh grade*

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Introduction

Although many components such as how learning takes place, what have influences on it, its transmission and quantity have not been fully clarified yet, the concept of learning is considered as the process of gathering knowledge from the environment with the help of certain strategies in an active and conscious way, and forming permanent behaviors by combining this knowledge with the existing knowledge in the memory (Namlu, 2004). While Riding and Stephen (1998) address learning as a holistic, creative information process realized between the individual and his environment, and the best form of comprehension where thoughts are formed by means of experiences; Bayindir (2006) defines it as an active process that can be affected and modified by the student. Considering mathematics and mathematics learning in this context; the content of the math textbooks, learning materials, time devoted to mathematics education, the scope of teaching methods, quality of teachers, learner's learning capacity and readiness, his cognitive and affective properties, past learning experiences and many factors can be said to have an impact on learning. Establishing the expected learning outcomes considering all of these factors can be made possible by the development of an effective curriculum. Indeed, with the teaching standards increasing within the last ten years; many European countries, including our country, have been reviewing the mathematics curricula in terms of learning outcomes and student needs on a regular basis (Bal, 2008; Cedefop, 2010; OECD, 2003; Psifidou, 2009). Hence, the importance of curriculum content becomes increasingly important for the desired student achievement, and learning objectives are also attempted to be dealt with in a more qualified way. Because, the proposed class time for math instruction usually varies between 20% and 15% of the total primary school teaching time (Eurydice, 2011). Therefore, the effective use of learning course time in achieving the learning goals has come to the fore. The proposed lesson time particularly for the mathematics class in primary and secondary schools (the curriculum time that mathematics is taught), as well as being a very important quality that helps explain the importance of a subject when compared with other, is closely related to degree of difficulty of the subject taught or the comprehension level of the learner (Eurydice, 2011).

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It is seen in the literature that there are various factors effective on mathematics learning such as; teacher's popularizing his lesson (Arici, 2013), attitudes towards the course (Hannula, 2002), listening to the course well (Dursun and Dede, 2004), training and professional development of mathematics teachers (Eurydice, 2011), ability of problem solving (Heppner and Lee, 2009), study time (Savas, Tas and Duru, 2010), growth and development properties (Thomson, Lokan, Lamb and Ainley, 2003) and self-efficacy (Hoffman and Spatariu, 2008). The dimension of teacher's teaching speed, which constitutes the basic starting point of the work and carried out and one of them is the size of the rate of learning with an operational dimension. According to Kardash and Howell (2000), the speed of learning involves beliefs about the nature of learning, as well as the features for the organization of knowledge. Accordingly, due to the changes arising from many factors, such as the thinking skills and learning capacity of each learner in a classroom setting, the amount of learning may vary. At this point, the question; *"how does the time-dependent change in the amount of students' learning take place among such variables?"* comes to mind. Thus, one of the most important reasons for the study conducted is to create a structure that will reveal the quantitative relation between time and learning. In a study conducted at the seventh grade level, *"solving problems that require establishing one-variable equations of the first order"* was discussed. 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, many studies are available on the subject of equations (Akkaya and Durmus, 2006; Bayar, 2007; Booth and Koedinger, 2008, Dede and Peker, 2007; Erdem, 2013; Soylu, 2008; Stacey and MacGregor, 2000). For example, the result of the study conducted by Dede and Peker (2007) on 99 students has revealed that students have errors and misunderstandings for algebraic operations and expressions. Another study was carried out by Akkaya and Durmus (2006) on 280 students. According to the results of the study, the students did not pay attention to the order of operations and did not take the importance of parentheses in the operations while using the variables. Booth and Koedinger (2008), in their study on 49 students, determined that students who had less knowledge of the equal sign and a negative sign made more mistakes in the questions on the subject and used wrong strategies in solving algebraic equations. Erdem (2013), in his study conducted on 193 seventh grade students, determined that the students had some errors and misconceptions on the subject of one-variable equations of the first order. Similarly, Soylu (2008) in his research on 50 seventh grade students concluded that students had problems in areas such as using variables in simple algebraic expressions, interpretation of variables, and limiting variables to certain letters. As well as these studies, it is possible to meet different approaches in the literature. For example, it was determined in a study conducted on 4942 students aged 15 years of age based on the structural equation model by Ozer and Anil (2011) that the variable predicting students' science and mathematics achievement most was *"the time allocated to learning".* Also according to the results of the research made by Kuru (2014), it was stated that the topic of equations came to the fore among the leading topics that students had learning difficulty in, and the reasons for the learning difficulties experienced in mathematics course were classified into four categories; including reasons stemming from students, reasons stemming from the learning environment, reasons stemming from the curriculum and reason stemming from teachers. In addition to the fact that the common focus of the studies conducted in the literature is learner-based; including reasons such as errors, misconceptions, misuse of strategies, variable interpretation also attracts attention. However, when examining the literature in a more detailed way, instead of stating that there is no study from this point of view it's better to state that this dimension has been scarcely investigated. Therefore, this study is expected not only to fill this gap but also to establish the importance of the course hours specified for the related gains in terms of the learner.

Consequently, the average course period allocated to the gain of *"solving one-variable equations of the first order",* which is included in the seventh grade mathematics curriculum in our country corresponds to 3.5 hours (Ministry of National Education [MNE], 2013). What is the relationship between the course periods set for this and this kind of gains and students' amount of learning? What level of learning do the learning groups or the learners reach in a specified course period? Moving from the above questions; the purpose of this study is to determine the amount of time-dependent learning of *"solving problems that require establishing of single variable equations of the first order"* of the seventh 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).

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	38	Female	P22	15	Male	P43	10	Female	P64	7	Female
P2	28	Female	P23	15	Female	P44	10	Male	P65	7	Female
P3	28	Female	P24	14	Female	P45	9	Male	P66	6	Female
P4	27	Female	P25	14	Male	P46	9	Male	P67	6	Male
P5	26	Male	P26	14	Female	P47	9	Male	P68	6	Female
P6	26	Female	P27	14	Female	P48	9	Female	P69	6	Female
P7	24	Female	P28	13	Male	P49	9	Male	P70	6	Female
P8	23	Female	P29	13	Female	P50	9	Male	P71	6	Male
P9	22	Female	P30	12	Female	P51	8	Female	P72	6	Male
P10	21	Male	P31	12	Male	P52	8	Female	P73	5	Male
P11	21	Male	P32	12	Male	P53	8	Male	P74	5	Male
P12	20	Female	P33	12	Male	P54	8	Male	P75	4	Female
P13	20	Male	P34	12	Female	P55	8	Male	P76	4	Male
P14	19	Female	P35	12	Female	P56	8	Male	P77	4	Male
P15	19	Male	P36	11	Male	P57	8	Female	P78	4	Male
P16	19	Female	P37	11	Male	P58	8	Female	P79	3	Female
P17	17	Female	P38	10	Male	P59	8	Female	P80	3	Male
P18	17	Male	P39	10	Male	P60	7	Female	P81	3	Male
P19	16	Male	P40	10	Male	P61	7	Male	P82	2	Male
P20	16	Female	P41	10	Female	P62	7	Female	P83	2	Male
P21	16	Female	P42	10	Female	P63	7	Female	P84	1	Male

Sample and Data Collection

The study group consists of a total of 84, 7th grade students, including 42 girls (50%) and 42 boys (50%), who attend a public secondary school in the province of Izmir, during the 2015-2016 academic year. In the study, the *"equations"* asked after the learning area was taught. The procedures to be performed on the study group are as follows:

- Determination of time-dependent learning amount of the learning group,
- Determination of time-dependent learning amount of the female learning group,
- Determination of time-dependent learning amount of the male learning group.

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. The scores that the students took from the measuring tool and their gender distributions are presented in the Table 1.

The data collection tool consists of the literature, teachers and the problems including the unit of equations prepared based on the secondary school seventh-grade math textbook. The secondary school seventh-grade math textbook taught in the academic year 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 is 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 19 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. In order to test the construct validity of the 12-item data collection tool developed, the Confirmatory Factor Analysis (CFA) was performed (x^2=55.277; p<0.01; x^2/sd=1.78; AGFI=0.84; CFI=0.94; RMSEA=0.08; IFI=0.94; GFI=0.91; NFI=0.88). As a result of the CFA applied; questions 3 and 4, whose factor loadings were not deemed eligible, were excluded from the measuring tool, and the Cronbach Alpha reliability coefficient of the final 10-item measuring tool was calculated as 0.86 (n=111). 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 40 and the minimum score as 0. The allocated time for the 4 learning outcomes whose lower learning areas are numbers and operations in the curriculum is defined approximately as 14 course hours (MNE, 2013). In this case, the time

Table 2. Sample problems and acquisitions

The content of the problem	Acquisition
Sample 1. Ms. Sinem goes walking for 1 hour for wellness every morning. She walks 200 meters more than the previous day in the same period of time, every morning. She walked a total of 6 km in three days, according to this, how many meters did Ms. Sinem walk the first day way? *Sample 2.* The number of ducks and cows in Ali Baba's farm is 24, and the total number of feet is 58. Accordingly, how many cows are there in the farm? *Sample 3.* The price for an adult cinema ticket is 10 Turkish Liras, and the discount ticket price is 8 Turkish Liras. The number of audience who bought adult tickets is 20 more than those who bought discount tickets. The box office collected in this session at the cinema is 920 Turkish Liras, so, what is the number of the audience who bought discount tickets?	Equations: The student solves problems that require establishing one-variable equations of the first order.

Table 3. 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

allocated for each acquisition, including the acquisition featured in our study consists of 3.5 course hours. The sample problems prepared in accordance with the acquisition and the acquisition they belong to are presented in the Table 2.

Analyzing of Data

SPSS 20.00 and AMOS software packages were used in the development of the measurement tool, and Graph software was used in drawing the graphs. The progressive scores scale in Table 3 below, which was developed by Marzano (2000), to analyze the 10 open-ended questions, which cover the acquisition of solving one-variable equations of the first order that belongs to the learning area of algebra and the lower learning area of equations which are in the Curriculum of Secondary School Mathematics Course was used (Grades 5, 6, 7 and 8) (MNE, 2013).

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:

$$\frac{dy/dt}{(y-y^2)^{\frac{3}{2}}} = \frac{2p}{\sqrt{n}} \quad \Rightarrow \quad \frac{4y-2}{\sqrt{y-y^2}} = \frac{2p}{\sqrt{n}} \cdot t + c$$

Findings and 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 Amount of Time-Dependent Learning 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 84 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= 10 [number of questions that reflect the characteristic of the acquisition]
- p= 989/84=11,77 [the average score obtained from the acquisition]
- t= 1,25 [learning time allocated to the acquisition]
- c= the parameter
- y= 1/2 [variable]

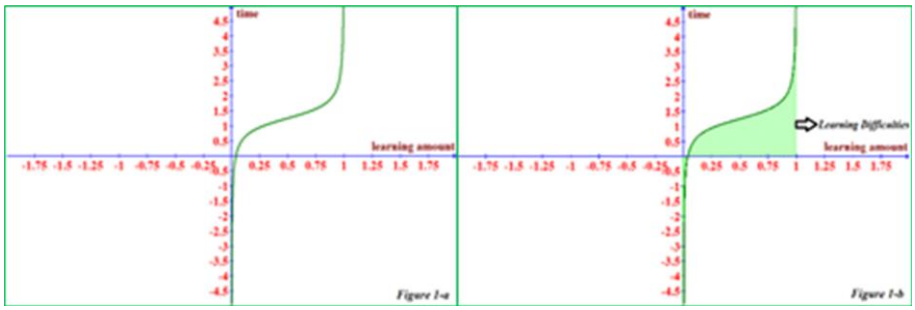

Figure 1-a,b: The graphics related to the amount of time dependent learning and the learning difficulties of the learning group

Table 4. 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	0.094	0.289	0.500	0.907	0.959	0.978	0.987*	0.991	0.999
Time	0.5	1.0	1.25	2.0	2.5	3.0	3.5	4.0	9.7

(*Lower limit for amount of full learning level)

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

y=1/2 the amount of half learning

$$\frac{dy/dt}{(y-y^2)^{\frac{3}{2}}}=\frac{2p}{\sqrt{n}} \quad \Rightarrow \quad \frac{4y-2}{\sqrt{y-y^2}}=\frac{2p}{\sqrt{n}}\cdot t+c \quad \Rightarrow$$

$$\frac{4.\frac{1}{2}-2}{\sqrt{\frac{1}{2}-\left(\frac{1}{2}\right)^2}}=\frac{2.11{,}77}{\sqrt{10}}.(1{,}25)+c \;\Rightarrow\; c\cong -9{,}31$$

$$\frac{4y-2}{\sqrt{y-y^2}}+9{,}31=\frac{2.11{,}77}{\sqrt{10}}.t \quad \Rightarrow \sqrt{10}.\left(\frac{4y-2}{\sqrt{y-y^2}}+9{,}31\right)=23{,}54t$$

$$\frac{\sqrt{10}.(4y-2)}{23{,}54.\sqrt{y-y^2}}+\frac{\sqrt{10}.9{,}31}{23{,}54}=t$$

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 above (Figure 1-a,b).

Examining the values in Figure 1 and Table 4; it is seen that there is a nonlinear correlation between time and amount of learning. The learning group reached the learning amount of 0.094 in course period of 0.5, the learning amount of 0.289 in a course period of 1.0; the learning amount of 0.500 in a course period of 1.25; the learning amount of 0.907 in a course period of 2.0; the learning amount of 0.959 in a course period of 2.5; the learning amount of 0.978 in a course period of 3.0; the learning amount of 0.987 in a course period of 3.5; the learning amount of 0.991 in a course period of 4; and the learning amount of 0.999, which is the full learning level, in a course period of 9.7. As the students get closer to the full learning level, the number of course hours needed and the area under the curve increase (Figure 1-b). Considering that the average of 3.5 course hours allocated to the related acquisition, it is observed that the learning group was behind the full learning level by a score of 0.013, and this corresponds to a 6.2 course hours. As the students get closer to the full learning level, the change in the time passed becomes clearer.

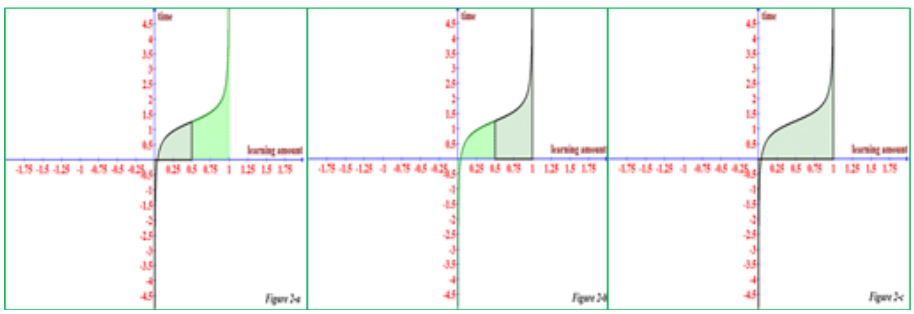

Figure 2-a,b,c: The graphics for learning difficulties of the learning group

Table 5. 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	0.001-0.500	0.500-0.999	0.001-0.999
Learning difficulties	0.372	0.875	1.248

In this case, the fact that the time needed for a learning amount of 0.009 (0.987-0.978) is equal to the time needed for a learning amount of 0.004 (0.991-0.987) can be given as an example. In addition to those described above, the curve's movement in the negative areas indicates the traces of the past learning situations of the group. Another conclusion that can be drawn from the data obtained is that multiplication of time in units by the amount of learning, in other words, the area above the curve gives the potential situation, that is, the learning difficulties. The following are the figures (2-a,b,c) showing the changes of the learning difficulties of the learning group in the range of learning amounts.

An analysis of the values given in Table 5 indicates a decrease in the amount of learning difficulties of the learning group when the area under the curve decreases (Figure 2-a,b,c). According to the table, when the range of learning amount is taken as 0.001-0.500, the learning difficulty becomes 0.372, when taken as 0.500-0.999, it becomes 0.875, and when taken as 0.001-0.999, it becomes 1.248. This situation shows us that new learning slow down and learning difficulties increase as the course hour progress, that is, learning occurs. When the area under the curve increases, 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 0.001-0.500 and in the learning difficulty in the range of 0.500-0.999. In short, as the learning difficulties increase, the amount of time needed for complete learning also increases.

Amount of Time-Dependent Learning of Female Students

The side is the calculations made to determine the amount of time-dependent learning of female students. The female learning group consists of a total of 42 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= 10 [number of questions that reflect the characteristic of the acquisition]
- p= 574/42=13,66 [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

$$\frac{dy/dt}{(y-y^2)^{\frac{3}{2}}}=\frac{2p}{\sqrt{n}} \quad \Rightarrow \quad \frac{4y-2}{\sqrt{y-y^2}}=\frac{2p}{\sqrt{n}}\cdot t+c \quad \Rightarrow$$

$$\frac{4.\frac{1}{2}-2}{\sqrt{\frac{1}{2}-\left(\frac{1}{2}\right)^2}}=\frac{2.13{,}66}{\sqrt{10}}.(1{,}25)+c \;\Rightarrow\; c\cong -10{,}8$$

$$\frac{4y-2}{\sqrt{y-y^2}}+10{,}8=\frac{2.13{,}66}{\sqrt{10}}.t \quad \Rightarrow \quad \sqrt{10}.\left(\frac{4y-2}{\sqrt{y-y^2}}+10{,}8\right)=27{,}32.t$$

$$\frac{\sqrt{10}.(4y-2)}{27{,}32.\sqrt{y-y^2}}+\frac{\sqrt{10}.10{,}8}{27{,}32}=t$$

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).

According to the values in Figure 3-a and Table 6; the female learning group reached the learning amount of 0.076 in course period of 0.5, the learning amount of 0.263 in a course period of 1.0; the learning amount of 0.500 in a course period of 1.25; the learning amount of 0.926 in a course period of 2.0; the learning amount of 0.969 in a course period of 2.5; the learning amount of 0.984 in a course period of 3.0; the learning amount of

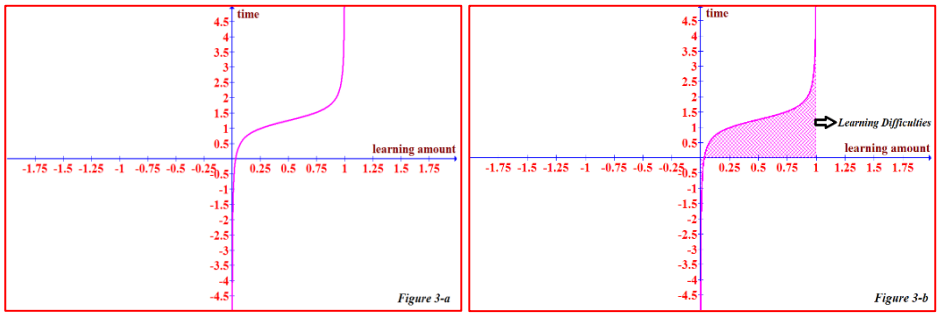

Figure 3-a,b: The graphics related to the amount of time dependent learning and the learning difficulties of the female learning group

Table 6. 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	0.076	0.263	0.500	0.926	0.969	0.984	0.987*	0.991	0.999
Time	0.5	1.0	1.25	2.0	2.5	3.0	3.2	3.6	8.5

(*Lower limit for amount of full learning level)

0.987 in a course period of 3.2; the learning amount of 0.991 in a course period of 3.6; and the learning amount of 0.999, which is closest value to the full learning level, in a course period of 8.5. Considering the level of 0.987, which is defined as lower level of complete learning in the study, and the time allotted for this learning outcomes in the curriculum; the time required for the female students to reach the complete learning seems to be lower than 3.5 course hours. In addition, as can be seen in Figure 3-a, the time required for the female student to reach the desired learning level extends to the infinity, and is located in the line of 8.5 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 0.015 (0.984-0.969) is equal to the time needed for a learning amount of 0.043 (0.969-0.926) can be given as an example. The following are the figures (4-a,b,c) showing the changes of the learning difficulties of the female learning group in the range of learning amounts.

An analysis of the values given in Table 7 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). According to the table, when the range of learning amount is taken as 0.001-0.500, the learning difficulty becomes 0.407, when taken as 0.500-0.999, it becomes 0.840, and when taken as 0.001-0.999, it becomes 1.247. This situation shows us that learning difficulties increase as the course hours increase just like in the learning group.

Amount of Time-Dependent Learning 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 42 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= 10 [number of questions that reflect the characteristic of the acquisition]
- p= 415/42=9,88 [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

$$\frac{dy/dt}{(y-y^2)^{\frac{3}{2}}}=\frac{2p}{\sqrt{n}} \quad \Rightarrow \quad \frac{4y-2}{\sqrt{y-y^2}}=\frac{2p}{\sqrt{n}}\cdot t+c \quad \Rightarrow$$

$$\frac{4.\frac{1}{2}-2}{\sqrt{\frac{1}{2}-\left(\frac{1}{2}\right)^2}}=\frac{2.9,88}{\sqrt{10}}.(1,25)+c \quad \Rightarrow \quad c\cong -7,81$$

$$\frac{4y-2}{\sqrt{y-y^2}}+7,81=\frac{2.9,88}{\sqrt{10}}.t \quad \Rightarrow \quad \sqrt{10}.(\frac{4y-2}{\sqrt{y-y^2}}+7,81)=19,76.t$$

$$\frac{\sqrt{10}.(4y-2)}{19,76.\sqrt{y-y^2}}+\frac{\sqrt{10}.7,81}{19,76}=t$$

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 5-a,b).

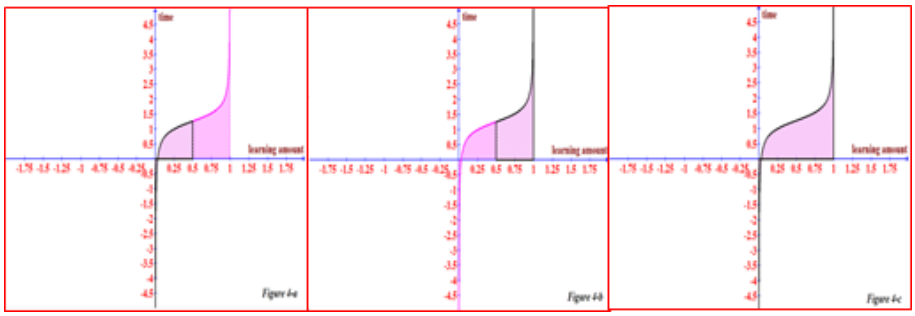

Figure 4-a,b,c: The graphs for learning difficulties of the female learning group

Table 7. 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	0.001-0.500	0.500-0.999	0.001-0.999
Learning difficulties	0.407	0.840	1.247

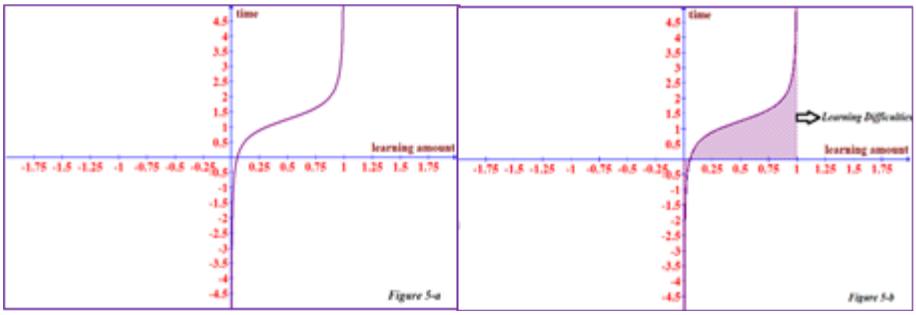

Figure 5-a,b: The graphics belonging to the amount of learning and the learning difficulties of the male learning group

Table 8. 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	0.120	0.319	0.500	0.881	0.945	0.970	0.987*	0.991	0.999
Time	0.5	1.0	1.25	2.0	2.5	3.0	4.0	4.5	11.3

(*Lower limit for amount of full learning level)

According to the values in Figure 5-a and Table 8; the male learning group reached the learning amount of 0.120 in course period of 0.5, the learning amount of 0.319 in a course period of 1.0; the learning amount of 0.500 in a course period of 1.25; the learning amount of 0.881 in a course period of 2.0; the learning amount of 0.945 in a course period of 2.5; the learning amount of 0.970 in a course period of 3.0; the learning amount of 0.987, which is the lower limit for complete learning, in a course period of 4.0; the learning amount of 0.991 in a course period of 4.5; and the learning amount of 0.999, which is closest value to the complete learning level, in a course period of 11.3. Considering the level of 0.987, 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 3.5 course hours. In addition, as can be seen in the curve of Figure 5-a, the time required for the male student to reach the desired learning level extends to the infinity, and is located in the line of 11.3 course hours at the level of 0.999, which is the closest value to the complete learning level. Similar to both the learning group and the female learning group, the fact that the graph curve belonging to the learning amount of the male 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 0.004 (0.991-0.987) is equal to the time needed for a learning amount of 0.025 (0.970-0.945) can be given as an example. The following are the figures (6-a,b,c) showing the changes of the learning difficulties of the male learning group in the range of learning amounts.

An analysis of the values given in Table 9 indicates a decrease in the amount of learning difficulties of the learning group when the area under the curve decreases (Figure 6-a,b,c). According to the table, when the range of learning amount is taken in the range of 0.001-0.500, the learning difficulty becomes 0.323, when taken in the range of 0.500-0.999, it becomes 0.924, and when taken in the range of 0.001-0.999, it becomes 1.265. This situation shows us that learning difficulties in the male learning group increase as the course hours increase just like in the learning group and the female learning group.

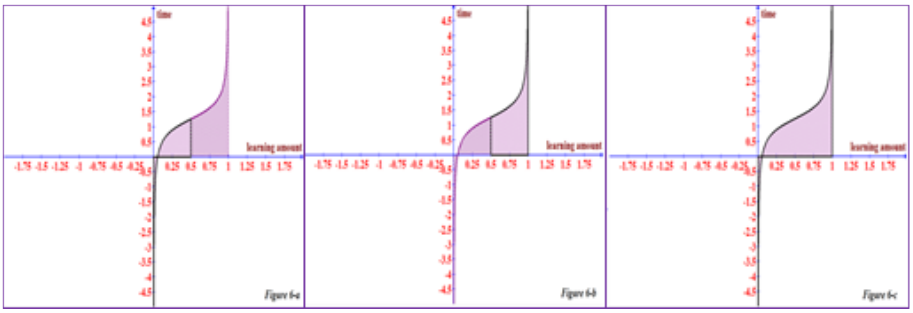

Figure 6-a,b,c: The graphs for learning difficulties of the male learning group

Table 9. 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	0.001-0.500	0.500-0.999	0.001-0.999
Learning difficulties	0.323	0.924	1.265

Discussion and Conclusion

In this section, the findings obtained from the study results that attempts to determine the amount of time-dependent learning of the male and female students in a learning group consisting of a total 84 students including 42 male and 42 female students, for whom the acquisition of *"solving problems that require establishing one-variable equations of the first order"* are addressed.

The time period allotted for the acquisition of solving one-variable equations of the first order, which belongs to the learning area of algebra and the sub-learning area of equations which are in the Curriculum of Secondary School Mathematics Course was determined to be 3.5 course hours on average (MNE, 2013). A total of 84 students whom we described as the learning group reached the learning amount of 0.987 in a period of 3.5 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 0.013 points behind the complete learning level. Despite this small deviation in the learning amount, a period of 6.2 course hours is needed for the closest value to the complete learning level. This time period corresponds to 248 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 also increase 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 to go from 0.907 to 0.959 and from 0.959 to 0.978 are the same can be shown as the strongest evidence of this situation.

Considering the relationship between the amount of learning and parameter values; the female students reach the lower limit of complete learning in 3.2 course hours, while the male students reach this limit in 4.0 course hours. The reason for the change in the times of both boys and girls can be due to the fact that the average point that the learning group obtained from the acquisition was 11.77, while this average was 13.66 in girls and 9.88 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 9.7 course hours, by the female students in 8.5 course hours, and by the male students in 11.3 course hours. 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 0.372 in the range of 0.001-0.500, the result rises to 0.407 in the female learning group, however, falls to 0.323 in the male learning group. While the learning difficulty of the learning groups is 0.875 in the range of 0.500-0.999, the score is 0.840 in the female learning group and 0.924 in the male learning group. Examining the learning amount range of 0.001-0.999, it is seen that the learning difficulty is 1.248 in the learning group, 1.247 in the female learning group, and 1.265 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 decreases, we can say that students experience fewer learning difficulties. 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. According to the report published by Eurydice (2011); the evaluation forms and criteria applied in secondary education, as well as the time (course hours) factor that students learn mathematics make an important contribution to student achievement. Through this study, the closest time of course hours to the complete learning level for each acquisition included in the curriculum can be obtained. Thus, contributions could be made to the creation of a more qualified and functional learning environment. Additionally, it could be easier to make measures in cases where students experience learning difficulties by monitoring each student's learning speed closely. Furthermore, the fact that the average scores taken by the learning group and the female and male learning groups from the measurement tool, in which the maximum score to be taken is 40, are located in the score range of 9 to 14 is consistent with the statement of Kuru (2014) that the topic of equations is the leading topic that student have the most learning difficulties. As a result, the most important contribution of this study to the literature is the fact that the closest periods of course hours to the complete learning level can be determined for each acquisition included in all level of education which determine learning objectives within a certain period and in all educational programs.

Notes

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

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