The Evaluation of the Cognitive Learning Process of the Renewed Bloom Taxonomy Using a Web Based Expert System

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ABSTRACT
The aim of this study is to develop the Web Based Expert System (WBES) which provides analyses and reports based on the cognitive processes of Renewed Bloom Taxonomy (RBT), and to put forward the impact of the supportive education provided in line with these reports, on the academic achievement and mastery learning state of the students. The study was carried out in a quantitative method, and pre-test, post-test matching control group model of semi-experimental designs have been used. A total of 50 students which are in 8th grade and also participate in supportive education have been selected (25 as the experimental group, 25 as control group) using the purposive sampling method. The experimental group has been given supportive education based on WBES system and the control group has been given the traditional supportive education. According to the conducted independent groups t-test and descriptive analysis, it's been found out that the method based on WBES is more effective than the traditional methods both in academic achievement rate and also mastery learning.

Keywords: Architectures for educational technology system; elementary education; evaluation methodologies; improving classroom teaching; teaching/learning strategies

1. INTRODUCTION

Education is a never ending process of life. This process is shaped as per the requirements of the society and goes on in a systematic way. The effectiveness of the educational institutions depends on the planned and purposeful execution of educational activities. The requirement of a system and plan in education brings with it the need for educational programs. Any educational program consists of three parts which are "aim, teaching process and evaluation". The aim which is the essential element of any educational activity acts as a guide for planning of the environment, efficiency and experiences (Anderson and Krathwohl, 2001; Bilen, 2002; Demirel, 2012; Ertürk, 1998; Varış, 1996). Aims define the features which are desired to be added to the student like knowledge, skills and attitudes (Anderson and Krathwohl, 2001; Bilen, 2002). Any aim that is added or desired to be added to any student is also defined as a gain. The gaining or changing of knowledge, skill, attitude and behaviors however is defined as learning (Schunk, 1991/2011). Teaching models are used for the learning and teaching of gains. One of the forefront of these models is the mastery learning model which offers an orderly teaching plan (Schunk, 1991/2011). This model is highly influenced from the "model of school learning" (MSL) of Caroll. It is based on the view that claims all the students can learn all the new behavior models that the schools aim to teach (Bloom, 1976; as cited in Schunk, 1991/2011). An important principle of this model proposes that the personal differences in between the students will be reduced along the process (Schunk, 1991/2011). In this model in which the teachers evaluate the development of the students and provide repeated or supportive courses, students develop their skills and continually need lesser time to learn (Schunk, 1991/2011).

The most common one among all the taxonomies which are based on the mastery learning model which determine the knowledge and skills desired to be given to the students and facilitate the mental process is the Original Bloom Taxonomy (OBT) (Bümen, 2006; Grounlund, 1998; Johnson and Fuller, 2006; Mcbain, 2011; Oermann and Kathleen, 2014; Özden, 2011; Poole, 2006; Valcke, Wever, Zhu, and Deed, 2009). This taxonomy, which was proposed by Benjamin Samuel Bloom in 1956, while developing the teaching strategies that support learning, also helps the students and ensures that the students progress from sub-level cognitive skills to high-level cognitive skills (Lovell-Troy, 1989). Machanick (1998) proposes that OBT should be taken as the basis for a more comprehensive review of the subjects which are taught in the teaching program.

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OBT was renewed by Anderson and Krathwohl (2001) as a result of changing educational requirements and innovations in learning (Bekdemir and Selim, 2008; Bümen, 2006; Huitt, 2009; Krathwohl, 2002; Turgut and Baykul, 2012; Zimmerman and Schunk, 2003). The Renewed Bloom Taxonomy (RBT) helps the teachers regarding the optimization and development of the educational programs (Raths, 2002). Raths also proposes that RBT is extremely effective for the compliance of activities and evaluations with the aims and the development of learning goals. Raths (2002) emphasizes on the consistency between RBT and Carroll's school learning model, and mentions the importance of focusing higher goals for a more effective education. RBT is important regarding its focus on high-level cognitive processes and emphasize on high-level cognitive dimensions. Executing a teaching program which will operate high-level cognitive processes is important for developing the necessary problem solving skills. Also, RBT is quite efficient to classify the problems (Lord and Baviskar, 2007; Manton, Turner, and English, 2004), which makes a suitable for developing problem solving skills (Krathwohl, 2002; Pintrich, 2002).

While the information and education technologies rapidly developing, the requirements and skills and behaviors that the students need to gain are also changing. In our day, the effective access to the information for individuals is more important than the amount of knowledge one has. Aybek (2006) states that high-level cognitive skills are important for individuals to be effective in accessing information and solving problems. Rather than having the knowledge, the concept of effectively learning and using knowledge using high-level cognitive skills has become more important. This task has been greatly undertaken by educational institutions and in line with the process, constant changes in educational systems do happen. However, current educational systems do now allow a mastery learning of targeted behavior with all its parameters. Thus, an effective control over the current educational processes is required. This control can be made in the way of an evaluation at the end of each level targeted, and provision of supportive education in order to mastery learning deficiencies and to reach the targeted behavior patterns (mastery learning) to reach the desired goals. One of the most effective learning models in this scope is RBT which consists of two different dimensions as knowledge (factual, conceptual, procedural, metacognitive) and cognitive processes (remembering, understanding, application, analysis, evaluation, creation) (Anderson and Krathwohl, 2001). Thompson (2008) suggests that RBT has been used all along for years while classifying the cognitive processes of students. Huitt (2009) suggests that students shall complete a lower level completely before passing to a higher level. Also Köğce and Baki (2009) as a result of their study, have suggested that teachers should also use questions that require higher cognitive skills like analysis, evaluation and creation, together with questions that require lower cognitive skills like remembering, understanding and application. When considered from this perspective, the Web Based Expert System (WBES) which was developed as a part of this study seems to cover all the levels of cognitive processes of RBT and prepare the environment for the use of all levels.

With the rapid development of technology, almost all sectors started to benefit from Information Technology (IT). With the development in educational technologies, the learning requirements have also been increased. This change has necessitated a change in the learning and teaching methods. In this process, rather than learning the information directly, learning it by configuring the information has become more important and it has become necessary for some theories to update themselves. Bloom Taxonomy, which was first proposed in 1956, despite receiving some criticism (Dam and Volman, 2004; Romiszows, 1986), still protects its efficacy and usability, and after being renewed in 2001 by Anderson and Kratwohl, its importance has also increased. Heavily used in the teaching-learning processes, this taxonomy is continuously researched and more effective teaching (mastery learning) is targeted to be provided through these researches. Studies conducted on this issue show that the questions, gains, goals and skills which are developed and used to evaluate the students do not cover all the levels of RBT and they are mostly directed at low level cognitive skills (Ayvacı and Şahin, 2009; Çalışkan, 2011; Gezer, Şahin, Öner-Sünkür, and Meral, 2014; Gündüz, 2009; Kocakaya and Gönen, 2010; Lord and Baviskar, 2007; Özcan and Akcan, 2010; Tüzel, Yılmaz, and Bal, 2013; Usta, Okur, and Aydin, 2014; Vick and Garvey, 2011). The research conducted suggests that students are mostly evaluated based on the lower level cognitive processes of RBT. This reveals that it is necessary to get to work in order to utilize the high level cognitive processes of RBT. And in this very study, our goal was to understand how to make the teaching process which is based on mastery learning, a more efficient and more effective one, with the inclusion of the developing internet and information technologies into the process.

Nowadays, technology undertakes the task to help people both physically and mentally. Expert systems which are one of these technologies, are tools that undertake to carry out the work rapidly and correctly, which would normally be made by experts on the field. Expert systems are computer programs which can model the decision making processes that could normally only be made by the experts (Nabiyev, 2003) and can solve problems as the experts of that field can solve (Daskalaki, Birbas, and Housos, 2004). Kılağız (1996) suggests that a good expert system can mimic the skills of an expert like designing, planning, diagnosis, evaluation, summarizing,

making generalizations, controlling and making suggestions. Yavaş and Civalek (2005) suggest that expert systems have the benefits of cost reduction, productivity, quality, reduction of operational errors, flexibility, reliability, and less response time. The WBES system which was developed in scope of this study shall be integrated in primary and secondary schools, and even private educational institutions, and help for the evaluation covering all the cognitive processes at the end of each subject, book or course. In this context, by the inclusion of all the levels of RBT regarding cognitive processes, through a web based expert system which makes evaluations regarding targets, a more applicable and mastery learning environment for both the students and the teachers have been tried to be provided.

The overall objective of this research; is to develop the WBES system which makes analysis and provides reports of RBT based on cognitive process dimensions, and to reveal the effect of the supportive education which is provided in line with these reports over the academic success of the students and mastery learning status. In this context, answers to the following questions were sought:

1. Is there any significant difference regarding the impact on academic success, between supportive education based on WBES and traditional supportive education?
2. How can the mastery learning status of the students according to RBT be described in the end of the supportive education based on WBES and the traditional supportive education?

2. METHOD

2.1. Research Design

The study was carried out in a quantitative method, and pre-test, post-test matching control group model of semi-experimental designs have been used. Quasi-experimental design is the design that is preferred when random assignment is not done (Fraenkel, Wallen, and Hyun, 2012, p.275). The independent variable of the study is the supportive education based on WBES, and the dependent variable is the academic success rate. After the experimental and control groups are given the standard education of the school, the experimental group was evaluated using the expert system and the control group was evaluated in the classroom (pre-test) and an Academic Success Test(AST) has been applied in order to measure their academic success. The experimental group was given supportive education based on the reports which are compliant with the RBT cognitive process dimension levels provided by the WBES system. The supportive education consisted of six stages and took 2 weeks to finish. Later on, students were re-evaluated using the expert-system (post-test). The visuals of the experimental group while solving the AST over the WBES system can be seen in figure 1.

Figure 1. Students using the WBES system.

The control group was applied the pre-test and was given the traditional supportive education. The supportive education of the control group also took 2 weeks. Both groups were educated by the same teacher. After the supportive education, a post-test was conducted.

2.2. Population and Sampling (Study Group)

The target population of this research consists of the eight grade students in İMKB Middle School in Midyat district of Mardin province of Turkey. The sampling was made using the purposive sampling method which is a non-selective sampling method. With this method, a total of 50 students which are in 8th grade and also participate in weekend supportive education classes have been selected. The courses of supportive education can hold a maximum of 25 students (Ministry of Education, 2014). Thus 25 students were selected as the experimental group, and another 25 as the control group. Also a mathematics teacher who provides supportive education to both groups was included in the sample.

2.3. Selection and synchronization of the groups

In the middle school which was selected as the target population, a mathematics test of 28 questions which is about one subject of mathematics that all the students that participate in the supportive education had learned. The students were ranked regarding the correct answer count that they had. Later on, based on the correct

answers, each group was included an equal amount of subjects based on the correct answer count. In the end, by considering the success factor, using the mechanical matching method, two equal separate groups have been formed. Mechanical matching method is the process of forming couples with similar two individuals with specific variable points (Büyüköztürk et al., 2012, p.207; Fraenkel et al., 2012, p.274). The groups which were formed using the above given methods, have been randomly selected as the experimental and control groups. Demographic information regarding the sampling group of the study is given in Table 1.

Table 1. Demographic Information about Research Sample

Groups	Female	Male	Total
Experimental Group	15	10	25
Control Group	13	12	25
Total:	**26**	**24**	**50**

If one observes Table 1, it is possible to see that experimental group consisted of 15 female and 10 male students, and the control group consisted of 13 female and 12 male students. It is possible to say that groups are quite similar regarding the gender distribution.

Before the AST was conducted, the equality of the experimental and control groups which were equalized using the matching method were rechecked and verified by conducting an independent group t-test. Also, with a Levene test, it's been seen that variances regarding the points were also equal. ($p_{(.367)}>.05$). The findings of the independent groups t-test is given in Table 2.

Table 2. Pre-test Independent Samples t-test Results of Experimental and Control Groups

Groups	*N*	Mean	*Standard deviation*	*Degrees of freedom*	*t*	*p*
Experimental Group	25	18.72	9.96	48	.833	**.409***
Control Group	25	16.24	11.06			

*p<.05

As seen on Table 2, the pre-test point average of the experimental group was calculated as 18.72, and their standard deviation has been found to be 9.96; on the other hand, the pre-test point average of the control group was calculated as 16.24, and their standard deviation has been found to be 11.06. As seen on the table, because $p_{(.409)}>.05$, it is possible to say that the differences between the groups is insignificant. This result confirms the academic equality of the groups.

2.4. Data Collection Tool and Data Collection Process

2.4.1. Academic Success Test (AST)

AST was developed according to the cognitive process dimension steps of RBT. AST was developed considering the distribution chart for the eighth grade mathematics lesson gains provided by the Ministry of Education, and a total of four basic gains among the algebraic expressions were selected. Face to face interviews were held with the expert mathematics teachers who were to provide the questions and they were presented with detailed information regarding the RBT. The subject of algebraic expressions were associated with lower cognitive processes which consist the six basic processes of the cognitive process of RBT, by the teachers who were considered to be adequately informed of the RBT subject and a total of 16 sub-gains were formed. Two separate tests that consist of 48 questions (6x8) that cover all the gains were formed. In order to ensure the conformity of the test questions to the RBT cognitive process dimension, four expert educators, one research associate and three mathematics teachers checked and revised the tests without harming their structure. The demographic information of the educators and the teachers are provided in Table 3.

Table 3. Demographic Information of Domain Experts

Line	Professional Status	N	Gender	The Faculty, department or school where s/he works
1	Professor	1	Male	Faculty of education – Computer Education and Instructional Technology-Maths
2	Associate doctor	1	Male	Faculty of education – Computer Education and Instructional Technology
3	Associate doctor	1	Male	Faculty of education – Primary education
4	Assistant Professor	1	Male	Faculty of education – Secondary education Science and Maths
5	Research Assistant	1	Female	Faculty of education – Primary education Maths
6	Math teacher	2	Male	Secondary School
7	Math teacher	1	Male	High school

The test that consists of 96 questions which were controlled and revised by the field experts were then applied to a pilot sampling group which consisted of 171 high school 1st grade students of Midyat Anatolian High School in order to make a validity and reliability analysis. p_j and r_{jx} values of the articles were calculated. As a result of the analysis, the questions with r_{jx} values lower than 0.20 have been excluded from the tests (N=28). As a result of the reliability analysis, the most suitable 42 articles have been selected and AST has been formed by using these articles as both pre-test and post-test (see Appendix A). At the end of the analysis, it's been seen that a reliability coefficient is .86. While the articles were selected, previous gains and compliance to RBT cognitive process dimension were considered. The questions were selected to include at least two questions for each gain. AST testing gains and p_j and r_{jx} values were provided in Appendix B.

2.5. Analysis of the data

Independent group t-test was conducted in order to determine whether there is any significant difference between the experimental group and the control group. By using reports based on WBES and academic success averages, mastery learning status according to the levels of RBT of both the experimental and control groups have been analyzed descriptively and presented in graphs.

2.6. Supportive education based on WBES

The students in the experimental group, after completing their formal education according to the curriculum of their schools, they solved the AST over the WBES system, over the web. Later on, the teacher who will provide the supportive education, pursuant to the reports he/she obtained from the WBES system, tried to teach the relevant subject in the weekend courses which is in the nature of a supportive education. A photo from one of these courses can be seen in Figure 2.

Figure 2. A photo from the supportive education provided based on WBES

Supportive education consists of six levels. Each student was taken to the one that he/she was lacking, which was determined in accordance with the reports provided by the WBES system. The realization of the supportive education was given in figure 3.

Figure 3. The realization process of the supportive education based on WBES

2.7. Web Based Expert System (WBES)

WBES system which provides an evaluation report which is in line with the cognitive process dimension levels of RBT was developed in scope of this study. With this developed system, the aim was to primarily execute the learning statutes which belong to the qualifications like the courses, lessons, seminars, in-service training which require mastery learning. This system provides a report to the teacher pinpointing the specific lessons and subjects to focus on for the supportive education, by checking if the mastery learning has been realized or not using a module (See Appendix C).

2.7.1. The development of WBES system

At first, WBES was negotiated with the different field experts (computer engineer, education expert, mathematics teacher, computer and education technologies expert), as the basic purpose and structure of the system has been presented and after the algorithms and flow diagrams of the system is published, system analysts were hired to check whether the system is operating or not. Later on, the programming languages, software and technologies that will be used were determined and researchers have been provided training in those fields. After the design of the interface, WBES system was programmed. An expert's point of view was taken regarding the system and it was updated as per recommendations. Also, by performing a usability test over the experimental group (N=25), possible errors of the system were tried to be detected and also, the experimental group was allowed to get acquainted with the system. The development process of WBES system was provided in figure 4.

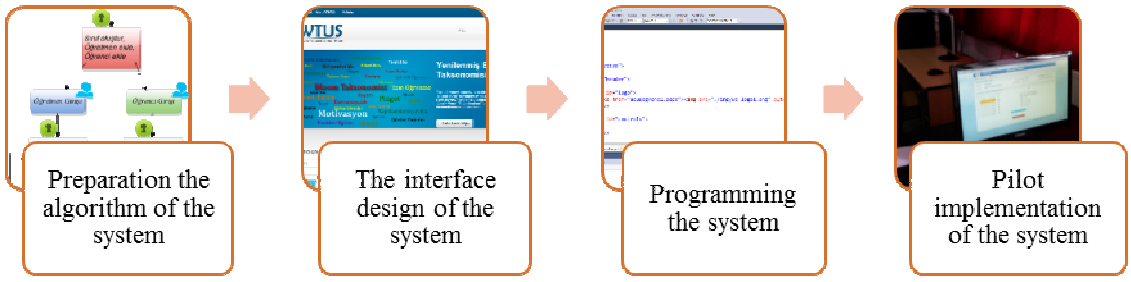

Figure 4. The development process of WBES system

Both the interface design and the programming of the WBES system have been made by researchers. For the interface design, image processing and modification programs like Fireworks, Photoshop were used. As editor and compiler, Visual Studio program was selected. The coding of the WBES system and suitable modules for RBT were made in VB language and technologies like Ajax, CSS, JQuery, Asp.net were used. SQL Server database was used as the data base solution. The developed WBES system was published in the web environment under the domain name www.wtusogretim.com.

In WBES system, interfaces for the student, teacher, and administrator are separate. The administrator identifies the teachers and the students to the system, with user id and password. The teacher can load to the system, questions which are suitable for the RBT cognitive process dimension and gains for these questions, teacher can also designate and modify tests. Teachers can also access the reports which provide the test results of the students pursuant to the RBT cognitive process dimension (see Appendix C). Students can log into the system and can solve the tests online that were designated for them from the interface that can be seen in figure 5.

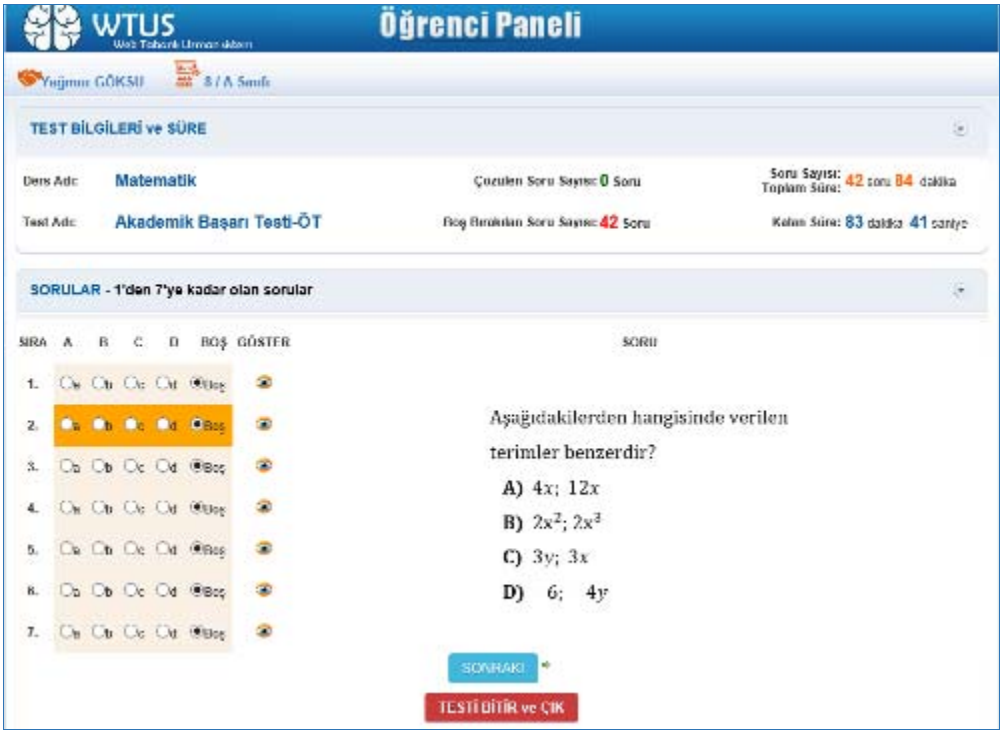

Figure 5. WBES online test interface

The teacher that is providing the course can upload the questions for this/her own class to the system, together with the question gains, in accordance with the RBT cognitive process dimension. It is mandatory for the teacher to have adequate information of RBT in order for him/her to make a reliable evaluation. The question uploading form can be seen in figure 6.

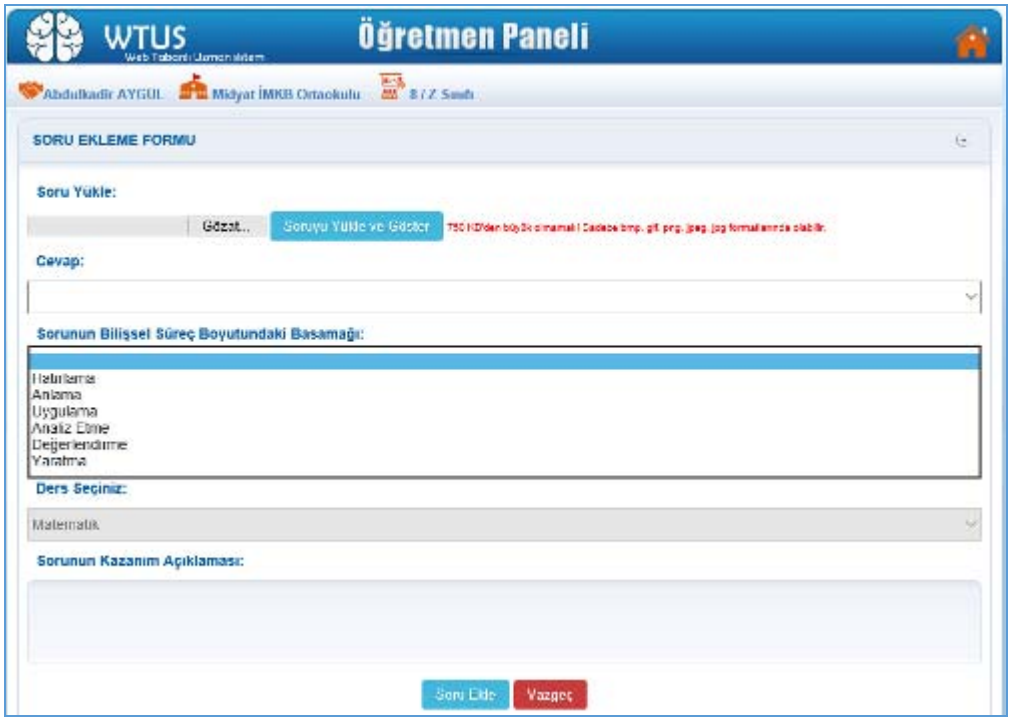

Figure 6. WBES question uploading form

In the question upload form which can only accept questions in bmp, gif, png, jpg or jpeg format, the right answer for the question and also its level regarding the cognitive process dimension of the RBT that it represents and the gain from the question can be uploaded to the system. The teacher can select questions from the question pool and create a test this way. After the selection of the test, the previously added number of questions to the

test can be listed in accordance with the levels of the cognitive process dimension of RBT. After the selection of the level, current questions in the pool can be listed. It is also possible to figure out which questions were added to the test, from this list. Test creation form can be seen in figure 7.

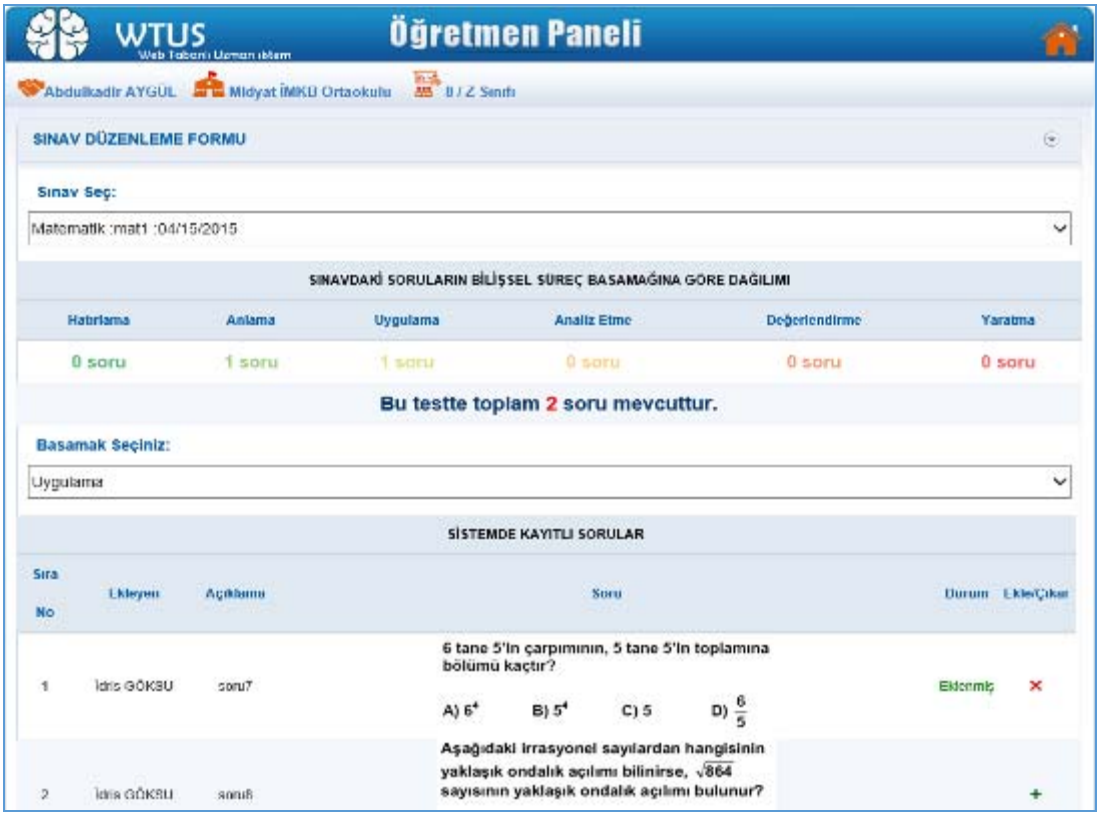

Figure 7. WBES test creation form

2.7.2. Reports which are suitable for the cognitive process dimension of RBT

The most important factor of the experimental process of the study is the student reports that the WBES system provides (See Appendix C). The main quality of this report is that it determines on which levels the students lacks gains and thus the exact levels that the student requires supportive education. When looked from this angle, it is possible to say that the work that normally belongs to the teacher has been taken over by the expert module of WBES system. While the system executes this task, and deciding on what levels the student is required to take additional courses, creating the review and procedure showings, it uses the rules written in Visual Basic.Net programming language which is shown in Table 4.

Table 4. Procedure Representation of Rules

	Condition	Operation
Incomplete competence rules	If $SP_{Remembrance}<85_{ICaz}$	$All_{AT} = All_{AT} + All_{Remembrance}$
	If $SP_{Comprehension}<85_{ICaz}$;	$All_{AT} = All_{AT} + All_{Comprehension}$
	If $SP_{Practice}<85_{ICaz}$;	$All_{AT} = All_{AT} + All_{Practice}$
	If $SP_{Analysis}<85_{ICaz}$;	$All_{AT} = All_{AT} + All_{Analysis}$
	If $SP_{Evaluation}<85_{ICaz}$;	$All_{AT} = All_{AT} + All_{Evaluation}$
	If $SP_{Creation}<85_{ICaz}$;	$All_{AT} = All_{AT} + All_{Creation}$
Comment rules	If $D_1 = 0$, $D_2 = 0$, $D_3 = 0$,	"In all steps additional training must be taken"
	If $D_1 = 0$, $D_2 = 0$, $D_3 = 1$,	"Successful in all steps and no need to take additional training"
	If $D_1 = 0$, $D_2 = 1$, $D_3 = 0$,	"Even though the success is good in all steps additional training is recommendable. But no need to take additional training in the steps."
	If $D_1 = 0$, $D_2 = 1$, $D_3 = 1$,	"Even though the success is good at D_2 step additional training is recommendable. But no need to take additional training at D_3 step.

If $D_1 = 1, D_2 = 0, D_3 = 0$,	"In all steps additional training must be taken"
If $D_1 = 1, D_2 = 0, D_3 = 1$,	"Must be taken additional training at D_1 step, no need to take additional training at D_3 step."
If $D_1 = 1, D_2 = 1, D_3 = 0$,	"Must be taken additional training at D_1 step. Even though the success is good at D_2 step additional training is recommendable."
If $D_1 = 1, D_2 = 1, D_3 = 1$,	"Must be taken additional training at D_1 step. Even though the success is good at D_2 step additional training is recommendable, but no need to take additional training at D_3 step."

D_1=Step$_{SP<70}$(The steps success percentage is below 70%, IC≥1)
D_2=Step$_{70\leq SP<85}$(The steps success percentage between 70 and 85, IC=1)
D_3=Step$_{SP\geq 85}$(The steps success percentage is 85 and higher than 85, IC≤1)
SP: Success Percentage, IC: Incomplete Competence, AT: Additional Training

3. FINDINGS

3.1. The comparison of the effects of supportive education based on WBES and Traditional Supportive Education over academic success

In order to see if there is any significant difference in the impact of the students' academic succes rates, between the supportive education provided based on the reports obtained from the WBES system and traditional supportive education, independent groups t-test has been applied. The post-test values that belong to both groups which were calculated with the AST which is the dependent variable and equal interval scale showed normal distribution. Deviancy ($Z_{(experimental,\ post\text{-}test)}$=-.541; $Z_{(control\ group,\ post\text{-}test)}$=.944) and oblateness values ($Z_{(experimental\ group,\ post\text{-}test)}$=1.129; $Z_{(control\ group,\ post\text{-}test)}$=1.264), histogram and Q-Q plot graphs show that the data has normal distribution. Levene test results regarding the post-test data of the AST experimental group and the control group showed the variances to be equal ($p_{(.236)}$>.05).

The data obtained regarding the independent groups t-test have been provided in table 5.

Table 5. Post-test Independent Samples t-test Results of Experimental and Control Groups

Groups	*N*	Mean	*Standard deviation*	*Degrees of freedom*	*t*	*p*
Experimental Group	25	26.52	11.630	48	2.153	**.036***
Control Group	25	18.96	13.148			

*p<.05

As seen in Table 5, the post-test point average of the students within the experimental group is $\bar{X}$=26.52 and their standard deviation is 11.630; and for the students in the control group the point average is $\bar{X}$=18.96 and the standard deviation is 13.148. It's been seen as a result of the conducted t-test of dependent groups, there is a significant difference between the post-test average of the experimental group and the post-test average of the control group ($t_{(48)}$=2.153; $p_{(.036)}$<.05). Thus, it is possible to say that the supportive education provided based on the WBES adds a significant difference to the academic success rate of the students compared to the traditional supportive education.

3.2. The mastery learning status of the groups according to the RBT levels of pre and post supportive education

When evaluated regarding mastery learning (85% and up) the change in the experimental group can be seen in figure 8.

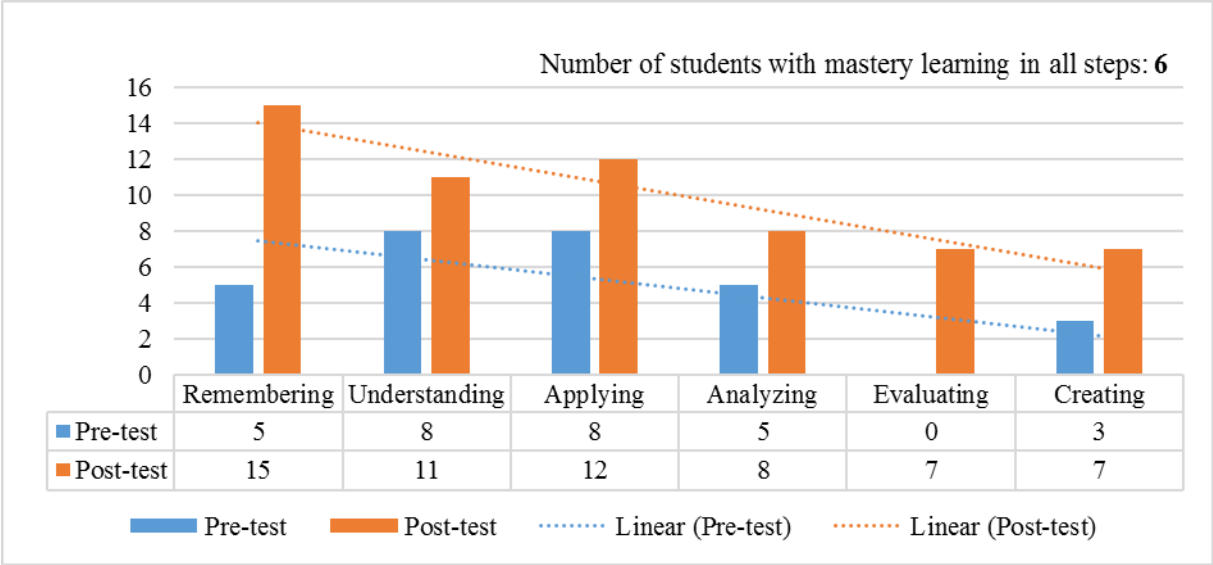

Figure 8. Mastery learning status before and after the supportive education based on WBES

As seen on figure 8, with WBES based supportive education, the number of students with mastery learning has increased with each new level. In the remembering level, pre-test results show 5 and post-test results show 15 students who completely learned. In the levels of understanding and application, it's been seen that as a result of the pre-test, 8 students had mastery learning, however after the supportive education, this number went up to 11 in the understanding level, and 12 in the application level. The pre-test results for mastery learning revealed that only 5 students learned completely in the level of analysis, and in the creation level it was 3 students only. In the evaluation level, no students could achieve mastery learning. After the supportive education however, the number of mastery learning students in the analysis and evaluation levels was 8, and it was 7 in the creation level. After the supportive educations given through the WBES based supportive education, 6 students could achieve mastery learning in all the levels.

The mastery learning status of the students after the traditional supportive education has been provided in figure 9. If observed, it is possible to see an increase in the number of complete learned students in the levels of understanding, application, evaluation and creation, after the traditional supportive education. In the remembering and analysis levels however, the number of completely learned students have diminished.

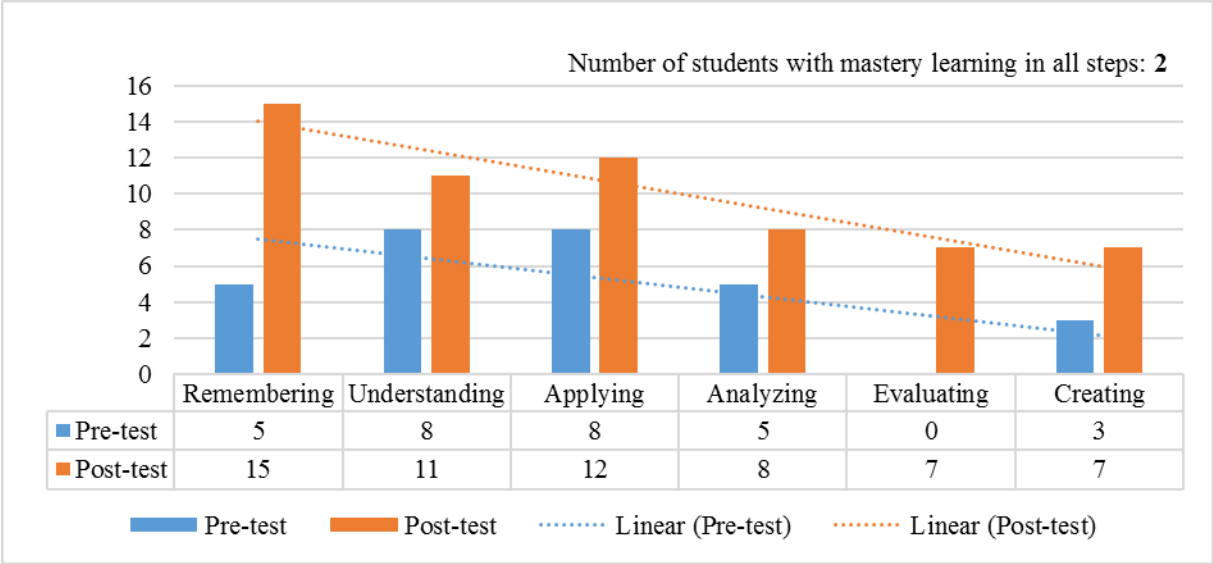

Figure 9. Mastery learning status before and after the traditional supportive education

According to figure 9, the number of completely learned students in the remembering level in the pre-test stage was 9, but after the post-test this number went down to 8. Similarly, while it was 4 in the analysis level, after the traditional supportive education this number also went down to 2. Besides, it's been seen that the number of completely learned students in the understanding level after the pre-test was 9, but this number went up to 10

after the supportive education, in the application level, the number went from 7 up to 10, in the evaluation level it went from 0 to 4 and in creation level it went from 2 to 4. After the supportive education provided by traditional ways, it's been seen that only 2 students achieved mastery learning in all the levels. The change in mastery learning status of both the experimental and control groups in accordance with the levels of cognitive processes of RBT was provided in figure 10.

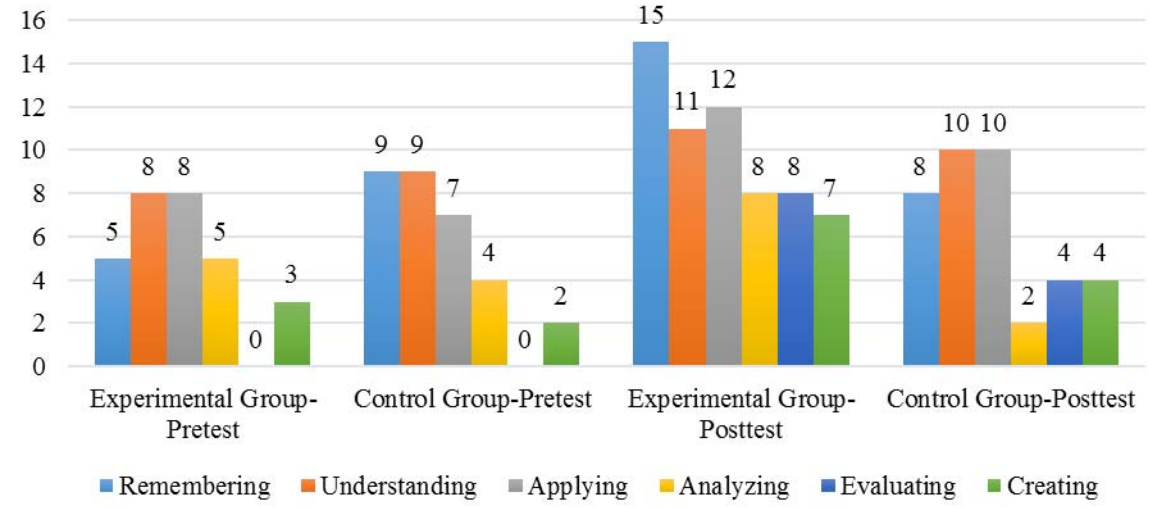

Figure 10. The change in the mastery learning status of the groups

According to figure 10, the number of completely learned students after the pre-test, in terms of the levels were pretty close to each other in both the experimental and control groups. It is clear to see that the difference gap has increased in favor of the experimental group after the post-test results. This actually shows that the WBES based supportive education is more effective regarding mastery learning. This result supports the result which states that the supportive education provided based on the WBES adds a significant difference to the academic success rate of the students compared to the traditional supportive education.

4. DISCUSSION

Independent group t-test was conducted in order to determine whether there is any significant difference between the impact on the success of the students in between the supportive education provided based on the reports obtained from WBES system and the traditional supportive education. As a result of this test, the post-test score average of the experimental group is found to be higher than the score average of the control group (X=26.52 / X=18.96) and the difference was found to be significant ($p_{(.036)}$<.05). In the end, it's been seen that the WBES based supportive education created a significant difference in the academic success of the students, compared to the traditional supportive education. Lamidi, Oyelekan, and Olorundare (2015) also reached a similar result and revealed that the education based on mastery learning is more effective than the traditional education. In various other studies, similar results have been erached and it's been suggested to use the mastery learning method in educational processes (Kularbphettong, 2014; Wambugu and Changeiywo, 2008; Yildiran and Aydin, 2005). The fact that the WBES based supportive education is based on the mastery learning model and RBT, also requires an evaluation from that aspect.

With WBES based supportive education, the aim has been to realize mastery learning. In this study, it's been seen that with WBES based supportive education, 6 students reached the mastery learning state in all the level of the RBT's cognitive process dimension (85% and up) and learned all the gains in all the levels of the RBT's cognitive process dimension. With traditional supportive education however, it's been seen that only 3 students reached the mastery learning state in all the level of the RBT's cognitive process dimension. It's been expected that with repeating supportive education, completely learned students would increase in numbers. The results obtained in this study actually strengthens the claim that mastery learning and RBT based education increases the academic success in a significant rate. Because many studies in various branches (Anderson et al., 1992; Bowen, 2006; Fier, 2007; Guskey, 2007; Miles, 2010; Thomas-Topp, 1995; Wambugu and Changeiywo, 2008; Whiting, Van-Burgh and Render, 1995; Yildiran and Aydin, 2005; Zengin, 2005) have shown that mastery learning affected the academic success in a positive manner. Some studies have also revealed that mastery learning is much more effective than traditional education techniques (Anderson et al., 1992; Block and Burns 1977; Kulik, Kulik, and Bangert-Drowns, 1990; Kurtuldu and Bakıoğlu, 2012; Nakajima, 2006). Also, Machanick (2005) emphasizes that education based on Bloom Taxonomy is much more effective than education based on traditional methods. Schunk (1991/2011) suggests that in supportive education provided in middle

schools, the use of mastery learning methods would allow the students to learn in their own pace and unlike traditional methods, would not stop students who want to progress fast.

5. RESULTS AND RECOMMENDATIONS

In this study a WBES system was developed which provides analyses and reports based on the cognitive processes of RBT, and through these reports, the impact of the supportive education on the academic achievement and mastery learning state of the students have been revealed. The impact on academic success rate was compared in between the WBES based supportive education and traditional supportive education. As a result, it is fair to say that WBES based supportive education brings a significant difference to the academic success of the students when compared to traditional supportive education methods. This result shows that WBES based supportive education is more effective than traditional supportive education. The number of students who achieved mastery learning according to RBT was more in the WBES based supportive education group, when compared to the traditional supportive education group.

Based on the results of the study, the following recommendations can be given to practitioners and researchers:

- ✓ The WBES system which was developed by Ministry of Education institutions in scope of this research or an expert system that will be developed based on this system can be coupled with the supportive education courses that are given in official or private middle or high schools. Thus, the students could learn their gains whenever and wherever they want, and school administrators can find out about the gains of all the students and prepare a supportive education based on the levels revealed and teachers can provide this education in accordance with the gains of the students. The parents will also be able to see the status of learning of their children. As a result, a more effective and efficient supportive education is expected.
- ✓ It is suggested to subject all the students which will participate in the supportive education programs, to a comprehensive test in the beginning of the semester, in order to determine their levels to form different classes. Also, this placement can be achieved based on the RBT over the WBES system.
- ✓ In this study, for each level of the RBT, it was assumed that students with a success rate of 85% and above achieved mastery learning in the level in question and was not taken to the supportive education class of that particular level. As stated by Block and Burns (1977), these students can also participate in supportive education classes and could help to other students who are having a hard time to achieve mastery learning, and thus, another study can be conducted which is based on WBES which also aims mastery learning.
- ✓ The developed WBES system is only compatible with RBT. Other taxonomies which will be used as grading systems can also be added to the WBES system and students can be evaluated based on a multitude of taxonomies.
- ✓ The expert system which was developed in scope of this study performs evaluations in accordance with some heuristic rules. A more useful, flexible and extensible system with different sizes can also be created by adding data mining algorithms to the system.
- ✓ By extending the duration of the supportive education courses based on WBES and mastery learning and by repeating the courses in any particular level, it would be possible to see how the mastery learning is affected by these procedures.

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Appendix A. Sample questions from AST (One in each level)

5. $x + 3y - 2x + 5 - y$ ifadesinin en sade hali aşağıdakilerden hangisidir?

A) $2y - x + 5$

B) $3y + x - 5$

C) $2y + x + 5$

D) $x - 2y + 5$

10. $2x + 12 = x + 7$

$3x - 2y = -21$

olduğuna göre y kaçtır?

A) 3

B) 2

C) 1

D) 0

15. $(x+4)^2$ ifadesinin eşiti aşağıdakilerden hangisidir?

A) x^2+16

B) $x^2+4x+16$

C) $x^2+8x+16$

D) $x^2-8x+16$

22. $(103).(97)$ çarpımı aşağıdakilerden hangisiyle ifade edilebilir?

A) 10^5-9

B) 10^4-9

C) 10^3-9

D) 10^2-9

29. $\frac{a^2-2ab}{2b^2-ab}$ ifadesinin sadeleştirilmiş şekli aşağıdakilerden hangisidir?

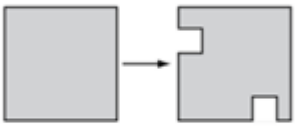
A) $\frac{a-b}{b}$

B) $\frac{-a}{b}$

C) $\frac{a+b}{a-b}$

D) $\frac{a}{a+b}$

41. Efe, proje ödevi için alanı **484** cm^2 olan kare şeklindeki kartondan, alanları otuz altışar santimetrekare olan iki kareyi şekildeki gibi kesip çıkarmıştır.



Kalan kartonun çevre uzunluğu kaç santimetredir?

A) 88

B) 112

C) 124

D) 136

Appendix B. The gains of AST based on RBT and p_j and r_{jx} *values*

ACADEMIC SUCCESS TEST				
		Gain	r_{jx}	p_j
1	**Remembering**	Remembering the concept of similar terms and addition in algebraic expressions	0.50	0.44
2		Remembering similar terms	0.37	0.70
3		Remembering addition and subtraction in algebraic expressions	0.52	0.63
4		Remembering the addition and subtraction and the concept of coefficient in algebraic expressions	0.30	0.71
5		Remembering the concepts of addition and subtraction in algebraic expressions	0.61	0.61
6		Remembering the concept of constant term	0.41	0.69
7		The making of addition and subtraction in algebraic expressions	0.61	0.64
8	**Understanding**	Knowing the concept of identity	0.52	0.75
9		Knowing the concept of identity, understanding the unknown	0.46	0.51
10		Finding the value of the unknown	0.63	0.67
11		Knowing the concept of identity	0.48	0.67
12		Knowing the concept of identity and mathematical procedure knowledge	0.74	0.60
13		Multiplying a single term expression with parenthesis which include more than one term	0.43	0.81
14		Multiplication of a single term expression with parenthesis that include more than one term	0.48	0.71
15	**Applying**	Writing the open version of the identity	0.67	0.39
16		Writing the open version of the identity	0.80	0.46
17		Writing the open version of the identity	0.80	0.44
18		Multiplying the parenthesis that include more than one term	0.63	0.58
19		Writing the open version of the identity	0.70	0.47
20		Writing the open version of the identity and making additions and subtractions	0.52	0.29
21		Multiplication of parenthesis that include more than one term	0.74	0.53
22	**Analyzing**	Factorizing the expressions	0.46	0.37
23		Factorizing and abbreviation	0.39	0.24
24		Factorizing and abbreviation	0.33	0.27
25		Factorizing and abbreviation	0.26	0.25
26		Factorizing and abbreviation	0.41	0.34
27		Factorizing and making additions, subtractions	0.74	0.30
28		Factorizing of the open expressions	0.43	0.29
29	**Evaluating**	Factorizing and abbreviating the fractional expressions	0.24	0.28
30		Factorizing and abbreviating the unknown coefficient expressions	0.30	0.29
31		Factorizing the fractional and crowded expressions	0.24	0.16
32		Factorizing and simplifying the expression	0.20	0.22
33		Factorizing and simplifying the expression	0.35	0.30
34		Factorizing the crowded expressions	0.39	0.18
35		Factorizing and abbreviating the crowded fractional expressions	0.20	0.30
36	**Creating**	Factorizing an expression by associating it with another	0.28	0.23
37		Finding the value of the unknown by factorizing the expression	0.24	0.18
38		Forming the equation with expressions with shapes and factorizing them	0.39	0.33
39		Forming the equation in the expressions given as problems and factorizing them	0.59	0.27
40		Finding the unknown by turning the shape expressions into algebraic form	0.50	0.55
41		Finding the unknown by associating the shape expressions with identities	0.26	0.26
42		The solving of questions which are associated with old subjects using identities	0.28	0.17

Appendix C. A report sample based on WBES (pre-test)

Test Seçiniz:

Matematik Akademik Başarı Testi-ÖT (03/21/2015)

Öğrenci Seçiniz:

Ayşe [redacted]

Test Sonuç Bilgileri

Öğrencinin Adı Soyadı: Ayşe [redacted] | Ders Adı: Matematik | Katılan Öğrenci Sayısı: 25

Sınıfın Başarı Yüzdesi: %44,57 | Test Adı: Akademik Başarı Testi-ÖT | Testteki Soru Adedi: 42

Öğrencinin Başarı Yüzdesi: % 78,57

Ayşe [redacted]'ın Yenilenmiş Bloom Taksonomisine Göre Başarı Durumu

HATIRLAMA	ANLAMA	UYGULAMA	ANALİZ	DEĞERLENDİRME	YARATMA
100 %	85,71 %	85,71 %	85,71 %	42,86 %	71,43 %
Doğru: 7	Doğru: 6	Doğru: 6	Doğru: 6	Doğru: 3	Doğru: 5
Yanlış: 0	Yanlış: 1	Yanlış: 1	Yanlış: 1	Yanlış: 3	Yanlış: 0
Boş: 0	Boş: 0	Boş: 0	Boş: 0	Boş: 1	Boş: 2

Hatırlama eksik kazanım	Anlama eksik kazanım	Uygulama eksik kazanım	Analiz eksik kazanım	Değerlendirme eksik kazanım	Yaratma eksik kazanım
	1. Özdeşlik kavramını bilme bilinmeyeni anlama	1. Özdeşliğin açık halini yazıp toplayıp çıkarma	1. Açık verilen ifadelerin çarpanlarına ayrılması	1. Çarpanlarına ayrırarak ifadeyi sade hale getirme 2. Kalabalık ifadeleri çarpanlarına ayırma 3. Kesirli ifadeleri çarpanlarına ayırıp sadeleştirme 4. Bilinmeyen katsayılı ifadeleri çarpanlarına ayırıp sadeleştirme	1. İfadeyi çarpanlarına ayırıp, istenen ifadenin değerini bulma 2. Eski konularla ilişkilendirilen soruların özdeşlikler kullanılarak çözülebilmesi

Hatırlama öğrenilen kazanım	Anlama öğrenilen kazanım	Uygulama öğrenilen kazanım	Analiz öğrenilen kazanım	Değerlendirme öğrenilen kazanım	Yaratma öğrenilen kazanım
1.Benzer terim kavramını ve cebirsel ifadelerde toplamayı hatırlama 2.Benzer terimi hatırlama 3.Cebirsel ifadelerde toplama çıkarma işlemini ve katsayı kavramını hatırlama 4.Cebirsel ifadelerde toplama çıkarma kavramını hatırlama 5.Sabit terim kavramını hatırlama 6.Cebirsel ifadelerde toplama ve çıkarma işlemlerinin yapılması 7.Cebirsel ifadelerde toplama ve çıkarmayı hatırlama	1.Özdeşlik kavramını bilme 2.Bilinmeyenin değerini bulma 3.Özdeşlik kavramını bilme 4.Özdeşlik kavramını bilme ve işlem bilgisi 5.Bir terimli bir ifadeyi birden fazla terim içeren parantezlerle çarpma 6.Bir terimli bir ifadenin birden fazla terim içeren parantezlerle çarpılması	1.Özdeşliğin açık halini yazma 2.Özdeşliğin açık halini yazma 3.Özdeşliğin açık halini yazma 4.Birden fazla terim içeren parantezleri çarpma 5.Özdeşliğin açık halini yazma 6.Birden fazla terim içeren parantezlerin çarpılması	1.İfadeyi çarpanlarına ayırma 2.Çarpanlarına ayırma ve sadeleştirme 3.Çarpanlarına ayırma ve sadeleştirme 4.Çarpanlarına ayırma ve sadeleştirme 5.Çarpanlarına ayırma ve sadeleştirme 6.Çarpanlarına ayırıp toplayıp çıkarma	1.Kalabalık ve kesirli cebirsel ifadelerin çarpanlarına ayrılması ve sadeleştirilmesi 2.Kesirli ve kalabalık ifadeleri çarpanlarına ayırma 3.Çarpanlarına ayırarak ifadeyi sade hale getirme	1. Şekilli ifadeleri özdeşliklerle ilişkilendirerek isteneni bulma 2.Şekilli ifadeleri cebirsel şekle çevirip isteneni bulma 3.Problem olarak verilen ifadelerde denklemi oluşturup çarpanlarına ayırma 4.Şekilli ifadelerde denklemi oluşturup çarpanlarına ayırma 5.Verilen bir ifadeyi başka ifadeyle ilişkilendirerek çarpanlarına ayırma

Öğrencinin Katılacağı Ek Eğitim Düzeyleri

1. DEĞERLENDİRME
2. YARATMA

*Bir düzeyde %80'nin altında başarı varsa, o düzeyde ek eğitim alınması önerilir.

Basamaklara Göre Başarı Grafiği (%)

Ayşe [redacted], HATIRLAMA (%100), ANLAMA (%85,71), UYGULAMA (%85,71), ANALİZ (%85,71), basamağında oldukça başarılıdır ve bu basamakta ek eğitim almasına gerek yoktur. YARATMA (%71,43), basamağında ise iyi düzeyde olmasına rağmen bazı kazanımları edinmediği tespit edilmiştir ve bu basamakta ek eğitim almalıdır. DEĞERLENDİRME (%42,86), basamağında ise oldukça eksiği olduğu tespit edilmiştir. Dolayısıyla yukarıda tespit edilen tüm eksik kazanımları edinmesi konuyu tam öğrenmesini sağlayacaktır.

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