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Research Article

Big Data Technology in Today's Education Systems: Learning Analytics

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Abstract

The concept of learning analytics emerges as a reflection of big data technology in the field of education to improve the quality of learning. Students leave large amounts of data from digital traces, especially during e-learning activities. These data can be processed to facilitate e-learning processes or to use for other educational and administrative purposes. Techniques such as predictive modeling, social network analysis (SNA), user, usage tracking, content analysis, semantic analysis, suggestion systems are among learning analytics techniques and learning analytics are used to identify and improve current learning process performance. Due to today's learning environments are digitalized, students are more lonely, their motivation is lower during e-learning activities, so managing the learning process is more difficult. Therefore, learning analytics applications come to the fore in today's education systems, just like virtual mentors. It will be easier to improve and manage the e-learning process, which has become more individualized through virtual mentors, compared to traditional education. In this study, an application study done before will be discussed in terms of how learning analytics can be adapted to educational institutions, and the adaptation of learning analytics application design (Learning Analytics Application Design, LAID) principles will be discussed with research questions. LAID consists of conceptual and logistical coordination, as well as the principle of coordination, comparison, and customization. The application data consists of the answers given to the learning tests applied in the Mathematics course by Sakarya University Electronic Technology distance education students at the associate degree level in the fall semester of the 2010-2011 academic year. The developed learning tests were first applied to Computer Programming students with similar characteristics, and after the item analysis was completed, updated tests consisting of the best questions were applied to the Electronic Technology students. Since participation in the tests is not compulsory, students who want to learn about their own learning performance participated in the published tests, and the number of participants varies between 88 and 107. Respectively, 107 students participated in sets tests, 93 students participated in numbers test, 101 students in algebra tests, 89 students in inequalities and equations tests, 105 students in functions tests, and 88 students participated in logarithm and trigonometry tests. Findings obtained, evaluation of the application in terms of learning analytics perspective, suggestions for improvement are given in the results section.

Keywords: Learning Analytics, Big data, Learning Process, Process Quality, E-learning

Günümüz Eğitim Sistemlerinde Büyük Veri Teknolojisi: Öğrenme Analitiği

Öz

Öğrenme analitiği kavramı, öğrenmenin kalitesini artırmak için eğitim alanında büyük veri teknolojisinin bir yansıması olarak ortaya çıkmaktadır. Öğrenciler, özellikle e-öğrenme etkinlikleri sırasında dijital izlerden büyük miktarda veri bırakırlar. Bu veriler, e-öğrenme süreçlerini kolaylaştırmak veya diğer eğitimsel ve idari amaçlar için kullanmak için işlenebilir. Tahmine dayalı modelleme, sosyal ağ analizi (SNA), kullanıcı, kullanım takibi, içerik analizi, anlam analizi, öneri sistemleri gibi teknikler öğrenme analitiği teknikleri arasında yer alırken, mevcut öğrenme süreci performansını belirlemek ve iyileştirmek için öğrenme analitiği kullanılır. Günümüz öğrenme ortamlarının dijitalleşmesi nedeniyle öğrenciler daha yalnızdır, e-öğrenme etkinlikleri sırasında motivasyonları daha düşüktür, bu nedenle öğrenme sürecini yönetmek daha zordur. Bu nedenle öğrenme analitiği uygulamaları tıpkı sanal mentorlar gibi günümüz eğitim sistemlerinde ön plana çıkmaktadır. Sanal mentorlarla daha bireyselleşen e-öğrenme sürecini geleneksel eğitime göre iyileştirmek ve yönetmek daha kolay olacak. Bu çalışmada, öğrenme analitiğinin eğitim kurumlarına nasıl uyarlanabileceği

açısından daha önce yapılan bir uygulama çalışması tartışılacak ve öğrenme analitiği uygulama tasarımı (Learning Analytics Application Design, LAID) ilkelerinin uyarlanması araştırma soruları ile tartışılacaktır. LAID, kavramsal ve lojistik koordinasyonun yanı sıra koordinasyon, karşılaştırma ve özelleştirme ilkesinden oluşur. Uygulama verileri, Sakarya Üniversitesi Elektronik Teknolojisi uzaktan öğretim öğrencilerinin 2010-2011 eğitim öğretim yılı güz döneminde ön lisans düzeyinde Matematik dersinde uyguladıkları öğrenme testlerine verdikleri cevaplardan oluşmaktadır. Geliştirilen öğrenme testleri önce benzer özelliklere sahip Bilgisayar Programlama öğrencilerine uygulanmış ve madde analizi tamamlandıktan sonra Elektronik Teknolojisi öğrencilerine en iyi sorulardan oluşan güncelleştirilmiş testler uygulanmıştır. Testlere katılım zorunlu olmadığı için yayınlanan testlere kendi öğrenme performansları hakkında bilgi edinmek isteyen öğrenciler katılmıştır ve katılımcı sayısı 88 ile 107 arasında değişmektedir. Sırasıyla 107 öğrenci kümeler testine, 93 öğrenci sayılar testine, 101 öğrenci cebir testine, 89 öğrenci eşitsizlikler ve denklemler testine, 105 öğrenci fonksiyonlar testine ve 88 öğrenci logaritma ve trigonometri testine katılmıştır. Elde edilen bulgular, uygulamanın öğrenme analitiği perspektifi açısından değerlendirilmesi, geliştirme önerilerine sonuçlar bölümünde yer verilmiştir.

Anahtar Kelimeler: Öğrenme analitiği, Büyük veri, Öğrenme süreci, Süreç kalitesi, E-öğrenme

1. Introduction

The Social transformation based on Industry 4.0 necessitates technology intensive restructuring of education systems. Developing human focused, competent, knowledgeable and skillful individuals are the basic requirements. Traditional educational institutions fall behind increasing demand. As a result of this, education deficit has been gradually growing. The concept of distance education is a consequence of the search for a solution. Increasing the number of students, educational demands made by different student populations, former students and working bringing with it a lifelong learning is the main driving force behind these developments (Dursun, Oskaybas and Gokmen, 2013). Future education systems should be based on innovation culture and technological capabilities. Education 4.0 is a concept that emerges when the fourth industry revolution changes the content and functioning of the education system. Educational systems, such as digitalized e-learning, VLEs (virtual learning environments) have come to the fore with the effect of developing and changing technology. On the other hand, new professions have emerged with Industry 4.0, and at the same time, some existing professions have been updated or lost their meaning. The knowledge, qualification framework and staff training will be an essential part of Industry 4.0 (Benesova and Tupa, 2017). The necessity of a new education approach that fosters people who are able to use information and produce new knowledge is indisputable. Technological developments affect the operation of the education systems and the concept of "Education 4.0" is on the agenda of the educational institutions due to recent progress. As to digital capabilities for educational instutions, the term is described as the application of technology to the core functions of an enterprise. It is possible for a higher education institution to prepare faculty to thrive in a next-generation digital learning environment and gain a competitive edge thereby developing e-learning capabilities and investing in e-learning technologies. E-learning has the potential to improve teaching and learning and can also lower barriers to higher education by offering flexibility with respect to when, where, and how students learn and faculty teach (Grajek, 2016). This concept is mainly summarized as digitalization in education, training as well as research and development systems. It differs from the traditional understanding of education with some interesting components such as customized education, augmented reality, virtual mentors, and learning analytics. It is now certain that the new mission of educational institutions is evolving towards generating innovative individuals with high-level thinking skills. In order to facilitate this, the digitalization of institutional processes seems to be inevitable. Analytics is a generic term used to perform analysis and this term used for statistical analysis, explanatory and predictive models. One of the specific usage named learning analytics (LA) uses these methods to achieve higher achievement in learning (Brown, 2012). The trend in contemporary education implementation is the shift from instruction design to learning design (Bozkurt, 2016). In this study, an implementation will be examined from the viewpoint of the learning analytics concept that one of the main components of the Education 4.0 level education institutions.

2. Learning Analytics (LA)

2.1 Occurrence of LA

In 2nd International Conference on Learning Analytics & Knowledge, learning analytics has been defined as “the measurement, collection, analysis, and reporting of data about learners and their contexts, for purposes of understanding and optimizing learning and the environments in which it occurs” (Society for LA Research; Brown 2012). As from 2011, adaptive technology in higher education gained recognition more widely, and after its maturing personalized learning was a great deal of discussion (Educase Horizon Report, 2020). In fact, personalized learning term is not new and Carol Ann Tomlinson who is one of the pioneers of differentiated education defined it as the adaptation of learning content, process and product according to the different readiness, interest and learning profile of the students (Tomlinson, 2014). The new here is the able to buy or build of digital platforms, applications and using big data technology. The maturation of learning analytics in higher education is affected by several factors such as leadership, cross-collaboration, and the coordination of technologies (Educase Horizon Report, 2020).

Learning analytics (LA) has at the top of the agenda of today's education systems as mentioned above. LA uses the learner individual and their learning processes data to improving learning systems based on evidence (Shum, 2012). Predictive modeling, social network analysis (SNA), user, usage tracking, content analysis, semantic analysis, suggestion systems are one of the learning analytics techniques and these techniques is used to identify and improve current learning process performance (Clow, 2013).

The shifting of learning processes transfer to online platforms has been increased in an unexpected way. Learning has become effective in online environments as well as in offline environments. Today's educational systems can collect and analyze the students'

digital traces and use these massive data called big data for an efficient feedback system to improve the e-learning process. The other related/similar concept called customized education is defined that a single organization, reaches out to the tertiary students with specific needs for an educational program. Regarding higher education, understanding the goals of higher education students, their learning styles, and the characteristics of learners are important elements in designing, delivering, and assessing courses to meet specific requirements. In the case of customized education, it is also necessary to take into consideration the needs of the industry and society, which will often include a transformational agenda (Bernon and Mena, 2013). But investing in adaptive technology only is not enough for the acquisition of learning outcomes which is the key to a meaningful education and many institutions have been confirmed this result by lessons learned from previous experiments of educational technology. It can be summarized some prominent LA practises as follows: (OECD 2012, Educase Horizon Report 2020).

i. Adaptive Learning in Elementary Spanish Language Courses: The University of Central Florida restructured the elementary Spanish language and civilization courses with this approach. Using adaptive learning and Open Educational Resources content they examined many problems for these courses and they gained results that more positive student perceptions and higher abilities.

ii. The Alchemy System: Personalized, Flexible, and Scalable Active Learning: The University of British Columbia developed the Alchemy learning platform that works for providing students with instant and specific feedback. Some of the important properties of this platform, make it possible to adapt delivery to different courses and curricula support flexible learning.

iii. Adaptive Learning in Teacher Education: At a study at Wisconsin University, it has been accomplished higher personalization and greater depth of learning approximately 50 percent of the content of a blended course by using adaptive learning. Professional Literacy Suite at Deakin University, BioSpine at Arizona State University, An Active and Adaptive Redesign of College Algebra at Oregon State University, and Student Success Using Learning Analytics at Iowa University are some of the important application examples of Adaptive Learning. Learning analytics has strength due to ensures the way to deliver unique designs for each learner, rather than reaching all learners with the same design. This ability can solve one of the main traditional education systems' problem called "one size fits all".

One of the examples of Learning Analytics Implementation Design (LAID) has been used three principles which are coordination, comparison, and customization (Wiley et al., 2020). Coordination principle has two aspects; conceptual coordination, logistical coordination. Corresponding of LA to educational objectives of the learning design is a necessity for conceptual coordination. This type of coordination is also compelling researchers to think that how terminal behavior, targetted outcomes would occurrence. The other coordination principle called logistical coordination is about giving support to teachers regarding when and how they access and use the LA. Variations of applications generally proceed from context, constraints, and preferences. The comparison principle has two aspects. One of the comparison principles is an absolute comparison based on an external, fixed standard such as rubric. Learning analytics uses similar entities such as education periods for relative comparison. Both principles are regarding the measures used to create analytics. The comparison principle is generally used for analysing the differences between the target level of learning outcomes and the realized level. For the customization principle implementing, researchers should be close together with teachers and system developers, and each teacher uniquely motivated and supported. Authors assume that for teachers which have a better understanding of their student's needs and generating a better pedagogical perspective, coordination, comparison, and customization principles have a significant role. At that point, it will be addressed an application obtained from a phd thesis (Dulger, 2012) regarding distance education student learning process evaluation with LA and LAID perspective. In the application, the purpose was to improve their e-learning process from the viewpoint of formative assessment.

2.2. Methodology

In the study, the learning performance of students of the Mathematics course of Sakarya University distance education was examined. The mathematics course of 7 units (sets, numbers, algebra, equations, functions, logarithm, and trigonometry) was first further developed as a modular approach divided into 28 SCOs (Sharable Content Objects). Subsequently, a learning performance test was developed for each learning object (LO). After the test items that measured the intended target behavior were first applied to the Computer Programming students for item analysis. Then, the most reliable and valid items were selected and applied to the students of the Electronics Technology Programme. The aim was to measure the performance of students with a view to it being used more extensively. Data consists of responses from students of The Electronic Technology Programme which offer distance learning at associate degree level in the fall semester of the 2010-2011 academic year and who wanted to know more about their own learning for formative purposes. Respectively; 107 people participated in the Sets test, 93 people participated in the Numbers test, 101 people participated in the Algebra test, 89 people participated in the Equations test, 105 people participated in the Functions test, 88 people participated in the Logarithm and Trigonometry tests. The steps of application can be listed as in what follows: Analysing maths course according to the modular approach, development of learning performance tests for measuring the learning outcomes, deliver to the first group (Computer Programming Program) on Learning Management System (LMS), validity and reliability analysis, implementation in the other group (Electronic Technology Program) on LMS, evaluation of results.

2.2.1 An example of LA Implementation Design (LAID)

Many e-learning systems managers prefer object based infrstucture due to efficiency. In this study learning objects used for learning unit. Learning objects configures independent of one another one, reusuable for different purposes and contexs, updatable, may be combinable for content creating, tagged with identifying information, pieces of information can be accessed over the network. In the study, the e-learning performance of students was examined. The mathematics course of 7 units (sets, numbers, algebra, equations, functions, logarithm, and trigonometry) was first further developed as a modular approach divided into 28 SCOs (Sharable Content Objects). The implementation stages of LAID principles can be seen below.

- *Conceptual Coordination Principle*

Qualification Of Mathematic based on Quality Assurance System

Interpret and evaluate data, define problems, do analysis, produce solutions based on proof with using basic level knowledge and practices gained within the field.

Restructuring Of Math

Mathematics course which consist of 7 units (sets, numbers, algebra, equations, functions, logarithm and trigonometry), can developed through a modular approach and divided into 28 learning objects.

Defining Learning Outcome Of Numbers Unit

He/She converts very small-very large numbers by processing with fractions. He/She operates with exponential-root numbers and equations. He/She solves absolute value problems; He/She converts number systems into each other.

Defining Learning Outcomes Of Each Learning Objects of Numbers Unit

For rational numbers, to be able to solve four operation and ranking problems in rational numbers. It has been defined for all LO - For rational, decimal, exponential, root numbers, absolute value, number systems.

Defining Learning Outcomes Of Each Information Objects

For rational numbers it has been four reusable information object (RIO). For ranking in rational numbers, the learning outcome of RIO is, he/she ranks rational numbers in different formats.

It has been structured the math course according to modular approcah and delivered to LMS as following below.

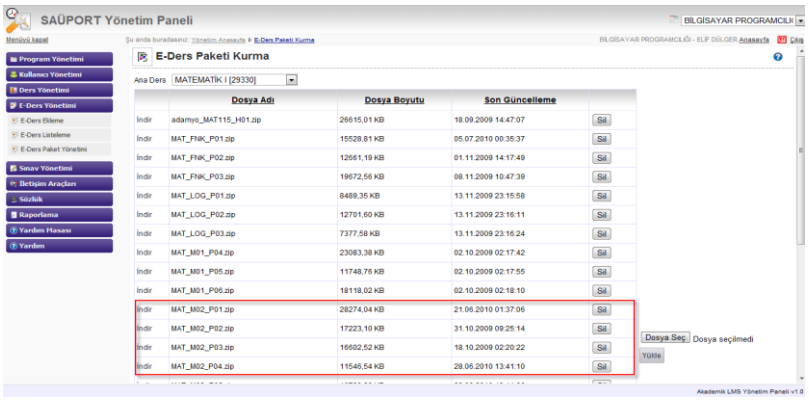

Figure 1. The mathematic course SCORM packages

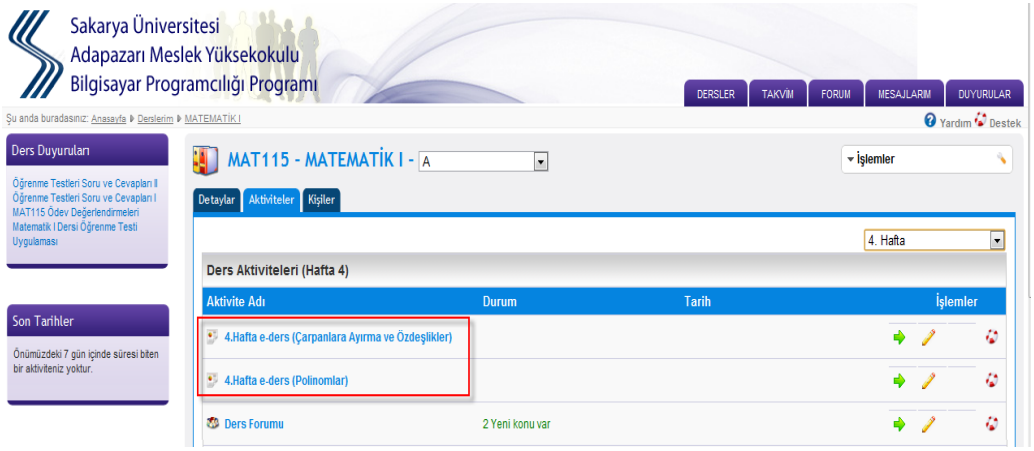

Figure 2. The mathematic course SCORM packages

Subsequently, a learning performance test based on qualification framework was developed, applied to test group for each learning object.

Figure 3. The mathematic course e-learning tests

Informing about the purpose of this tests can be seen in Figure 4.

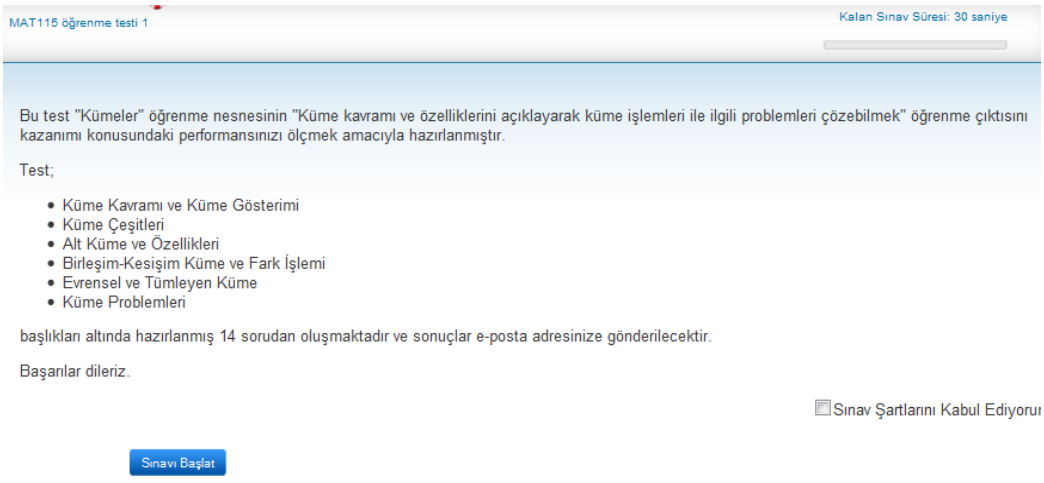

Figure 4. Information display of Sets Learning Object Learning Test

The questions have been formed appropriate to measure the breakdowns of learning outcomes. All breakdowns of learning outcomes have been defined respectively to monitoring throughout the process to intervene. It can bee seen an example for numbers unit and its objects in Figure 5 (Dulger and Merrell, 2017).

	UNIT		RLO	Learning Outcomes of RLO		RIO	Learning Outcomes of RIO
2	NUMBERS	2.1	RATIONAL NUMBERS	To be able to solve four operation and ranking problems in rational numbers	2.1.1	Fraction, fraction types, simplification and expansion of fraction	He/she can make operations related to fraction concept and features
					2.1.2	Four Operations in Rational Numbers	He/she solves problems related to rational numbers
					2.1.3	Infinite Fractions	He/she solves problems when the numerator and the denominator of a fraction goes infinite
					2.1.4	Ranking in Rational Numbers	He/she ranks rational numbers in different formats
		2.2	DECIMAL NUMBERS	To be able to do decimal fraction operations given by decimal numbers, to be able to do conversion in repeating decimal numbers and in too big - too small numbers	2.2.1	Four Operations in Decimal Numbers	He/she solves problems related to decimal and repeating
					2.2.2	Too Big - Too Small Numbers	He/she converts numbers which positive and negative powers of "10" to decimal fractions
		2.3	EXPONENTIAL NUMBERS	To be able to be operation using exponential numbers and its features, to be able to solve related to exponential equations and inequalities	2.3.1	Exponential Numbers and Features	He/she recognizes the concept of exponential numbers and express its features
					2.3.2	Operations with Exponential Numbers	He/she solves problems related to exponential numbers
					2.3.3	Exponential Equations and Inequalities	He/she solves problems related to exponential equations and inequations
		2.4	ROOT NUMBERS	To be able to interpret the relationship between root and exponential numbers, to be able to use the root number properties and perform operations, to be able to solve problems related to root equations and inequalities	2.4.1	Root Numbers and Features	He/she recognizes the concept of root numbers and
					2.4.2	Operations with Root Numbers	He/she solves problems related to root numbers
					2.4.3	Root Equations and Inequalities	He/she solves problems related to root equations and inequations
					2.4.4	Operations with Exponential&Root Numbers	He/she can interpret relationship between exponential and root numbers
		2.5	ABSOLUTE VALUE	To be able to be operation related to the concept of absolute value, to be able to solve problems of absolute value inequalities	2.5.1	Concept of Absolute Value and Operations	He/she solves problems belong to absolute value of a real number
		2.6	NUMBER SYSTEMS	To be able to make transactions about binary, octal, hexadecimal numbers, to be able to solve the problem by number converting from ten base to wanted base	2.6.1	Decimal-Binary-Octal-Hexadecimal Number Systems	He/she can make operations related to binary, octal, hexadecimal numbers in number systems
					2.6.2	Convert from decimal base	He/she converts from decimal base to wanted base

Figure 5. Outcome definitions for numbers unit learning objects (RLO) and information objects (RIO)

- *Logistical Coordination Principle*

After the test items that measured the intended target behaviour were first applied to the Computer Programming students who were the subject group, item analysis (difficulty index, discrimination index and test reliability) was performed. The tests developed, written, administered and the materials were evaluated by a group of four specialists one of whom was a subject matter expert, one of whom was a measurement and assessment expert, one of whom was the system manager and the other of whom was the author of this paper.

Item and Test Analysis Program -- ITEMAN (tm) for Windows Version 3.50
Item analysis for data from file C:\ITEMANW\ ESITSIZ.DAT
**********ANALYSIS SUMMARY INFORMATION **********
Type of Scale DICHOT
N of Items 8
N of Examinees 53

Seq. No.	Scale -Item	Prop. Correct	Disc. Index	Point Biser.	Alt.	Prop. Total	Endorsing Low	Endorsing High	Point Biser.	Key
1	1-1	.30	.68	.71	A	.19	.19	.11	-.22	
					B	.21	.38	.00	-.33	
					C	.13	.31	.05	-.28	
					D	.13	.13	.16	-.02	
					E	.30	.00	.68	.71	*
					Other	.04	.00	.00	-.05	
2	1-2	.49	.62	.47	A	.15	.19	.26	.06	
					B	.49	.06	.68	.47	*
					C	.04	.13	.00	-.25	
					D	.23	.56	.05	-.41	

Alpha	0.583
SEM	1.248
Mean P	0.370
Mean Item-Tot.	0.503
Mean Biserial	0.645
Max Score (Low)	1

Then, the best items selected and applied to the students of the Electronics Technology Programme.

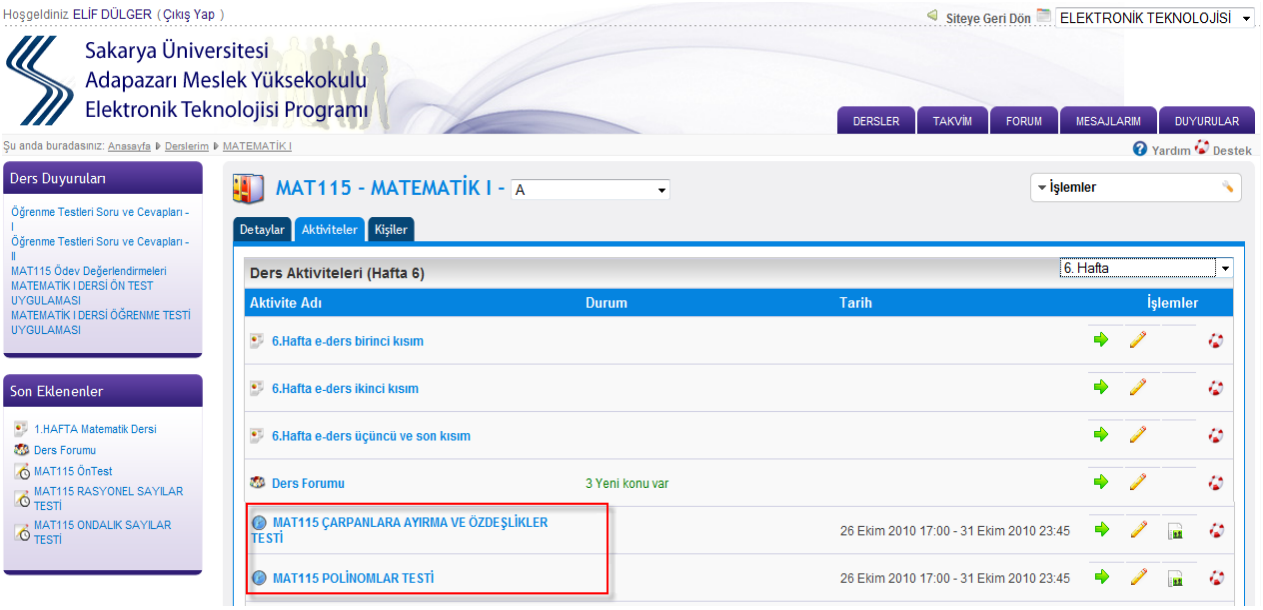

Figure 6. Implementation of the verified performance test to the Electronic Technology Programme Students

- *Comparison Principle*

Data consists of responses from students of The Electronic Technology Programme which offer distance learning at associate degree level in the fall semester of the 2010-2011 academic year and who wanted to know more about their own learning for formative purposes. If the measured learning performance is above 50%, it is accepted as successful and below it as unsuccessful, and this acceptance has been a guide in the feedback given to the students. It is thought that the absolute comparison which is the principles of comparison principles is matched this approach.

- *Customization Principle*

In the study, firstly their learning performance was measured on the basis of learning outcome level, and it was stated that they had to re-work on the object they performed below 50%. As can be seen from the Figure 7, the performances of the students regarding the learning objects and their sub-breakdowns are included separately, and the student was informed about the learning outcome acquisition. The results were sent to the e-mail addresses of the students via a software as shown in Figure 7.

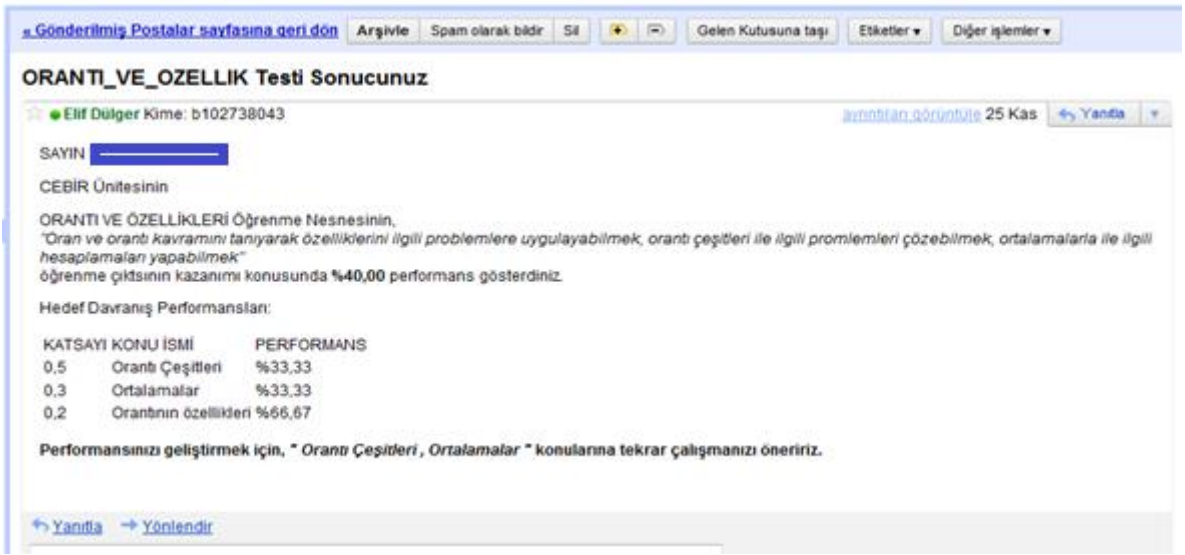

Figure 7. Customized report example about e-learning performance for learning object

As can be seen from the Figure 8, guidance was made for individual questions via mathematic course forum in LMS to improving their learning performance, if needed.

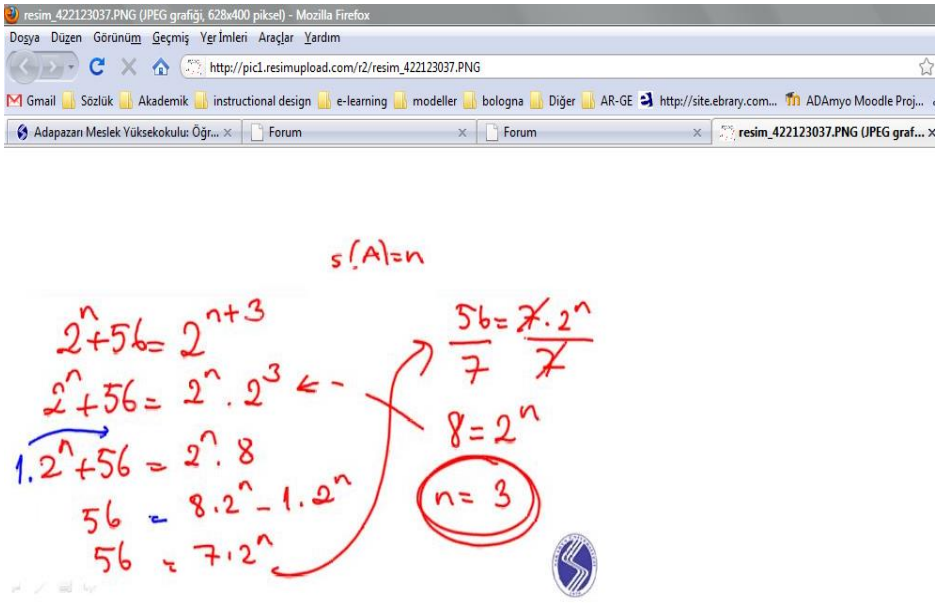

Figure 8. A guidance example for individual questions to improving their learning performance

3. Findings and Results

For Electronic Technology Program students; Sets 72.98% Numbers 68.10% Algebra 65.33% Equations and Inequalities 78.60% Functions 59.87% Logarithm 51.09% Trigonometry 40.32% results were obtained at the point of learning outcomes. One of the consequences is the trigonometry unit that is the most challenging for the Electronic Technology Programme students, with the lowest performance. The other consequence is the equations unit that is the easiest for the Electronic Technology Programme students, with the highest performance. It is thought that LAID principles are matchup to the previous studies and useful for understanding student learning that is the initial condition of Learning Analytics. Restructuring the mathematical course with a modular approach based on RLO and RIO is appropriate to coordination principle. For comparison principle, basic assumption was %50. Another thought is, it should be more detailed for personalization more especially for successful ones and provide additional sources and guidance. As to the informing pedagogical action, it is thought that the current implementation useful for the customization principle.

4. Conclusions

Learning Analytics has a significant role for today's education systems effectiveness because of can makes possible intervene on-time, manage and shape learning process, to prevent low performance, gaining good quality product (dissertation, student projects and other student studies). E-learning has become widespread due to such reasons as access flexibility, eliminating geographical barriers, and improving convenience and effectiveness for customized and collaborative learning. On the other hand, it could be said that it has some drawbacks such as lack of peer contact and social interaction, high initial costs for preparing multimedia content materials, substantial costs for system maintenance and updating, as well as the need for flexible tutorial support (Wu et al., 2009). With this study, a systematic approach restructuring the e-course with regard to quality assurance system was created and thus the acquisition of learning outcomes could be easier. While doing this, modularity- which was an important approach for distance education- was adopted, and the degree of acquisition of defined learning outcomes for each learning object was analyzed. In the implementation, it has been analyzed the components of learning math and learning performance tests generated for each learning object to monitor student's learning performance to be able to intervene in their learning process, if needed.

This implementation executed for electronic technology program students and it is thought that the created software for personalized suggestions were an useful example for customized education. Within the scope of the study, it has been evaluated their e-learning performance but after advices, no more action made for tracking their new learning situation. To complete the loop for continuous improvement, it is thought that we should perform a second measurement to ensure increasing learning process quality using LAID and this approach should extend to whole e-learning students.

References

Benesova A., Tupa J. (2017). "Requirements for Education and Qualification of People in Industry 4.0, 27th International Conference on Flexible Automation and Intelligent Manufacturing, Italy

Bernon M, Mena C. (2013). "The evolution of customised executive education in supply chain management", Supply Chain Management: An International Journal, Vol. 18 Issue: 4, pp.440-453, https://doi.org/10.1108/SCM-07-2012-0262

Brown, M. (2012). "Learning Analytics: Moving from Concept to Practice", ELI Briefs, Educase Learning Initiative, https://library.educause.edu/resources/2012/7/learning-analytics-moving-from-concept-to-practice, Access date: 05.06.2020

Bozkurt, A. (2016). "Öğrenme analitiği: e-öğrenme, büyük veri ve bireyselleştirilmiş öğrenme". AUAd, 2(4), 55-81.

Clow, D. (2013). "An overview of learning analytics". Teaching in Higher Education, 18(6) pp. 683–695.

Dursun T, Oskaybas K, Gokmen C. 2013. "The Quality Of Service Of The Distance Education." 13th International Educational Technology Conference. Procedia - Social and Behavioral Sciences. 103: 1133 – 1151 doi: 10.1016/j.sbspro.2013.10.441

Dülger E., (2012). "Yükseköğretimde uzaktan eğitim performansinin ölçme ve değerlendirilmesi için bir model önerisi", Doktora tezi, Sakarya University, Turkey

Dülger, E., Merrell C. (2017) "Evaluation of the Mathematics Performance of Distance Education Students with Rasch Model in Higher Education: Sakarya University Case Study.", 11th Annual Rasch User Group Meeting, University of Warwick, UK.

Educase Horizon Report. (2020). Teaching and Learning Edition, https://library.educause.edu/resources/2020/3/2020-educause-horizon-report-teaching-and-learning-edition, Access date: 15.09.2020

Grajek, S. (2016). "Digital Capabilities in Higher Education, 2015: E-Learning" Research repor, Louisville, CO: ECAR. https://library.educause.edu/~/media/files/library/2016/8/ers1606.pdf, Access date: 01.04.2017

OECD Report. 2012. Assessment Of Higher Education Learning Outcomes. AHELO Feasibility Study Report. Vol 1. Design and Implementation.

Shum, B. (2012). Learning Analytics. UNESCO Policy Brief.http://iite.unesco.org/files/policy_briefs/pdf/en/learning_analytics.pdf (Access date: 05.10.2016)

Society for Learning Analytics Research (SOLAR), https://www.solaresearch.org/core/, Access date: 15.08.2019

Tomlinson, C.A. (2014), "Öğrenci Gereksinimlerine Göre Farklılaştırılmış Eğitim", Sev Yayınları

Wiley K.J., Bradford A., Dimitriadis Y., Linn M.C. (2020). "From Theory to Action: Developing and Evaluating Learning Analytics for Learning Design", LA and Knowledge (LAK '20), March 23–27, 2020, Frankfurt, Germany.

Wu, Jen-Her, Robert D. Tennyson and Tzyh-Lih Hsia. 2009. "A study of student satisfaction in a blended e-learning system environment." Computers & Education 55: 155-164, doi: 10.1016/j.compedu.2009.12.012