USING E-STUDY MATERIALS TO PROMOTE MATHEMATICS SELF-LEARNING AT UNIVERSITY

Anna Vintere[1], Sarmite Cernajeva[2] and Vera Gosteine[2]
[1]Latvia University of Life Sciences and Technologies, Liela Street 2, Jelgava, Latvia, LV-3001
[2]Riga Technical University, Zunda krastmala 10, Riga, Latvia, LV-1048

ABSTRACT

At present, issues of the education system and quality improvement are topical in the whole world. Today, universities need to be prepared to offer young people education that makes them competitive in these new working conditions. When considering development of the education, they shall understand necessity of changing both content and form of the studies. As today's youth grow in an era of digital technologies and is dwelling in a virtual environment, they increasingly are demanding flexible study format that complies with their usual habitat. Therefore, the main task of universities and other higher educational establishments at this time of change is to develop intellectual skills, exploratory research attitudes and build ICT skills in a new specialist. Mathematical study programs and didactics need to be improved on the basis of ICT (paying more attention to the application of mathematics, including using ICT), creating modern technology-based learning materials and ensuring the Internet access. In order to increase students' responsibility for the learning process and to promote the ability to independently acquire knowledge, skills and abilities, it is necessary to create the preconditions for self-directed learning in higher education institutions, that is, students themselves participating in setting the purpose of studies, planning the acquisition of the subject, presentations, and evaluating their work together by agreeing on final assessment with the assessment of peers and teachers. As known, e-studies and self-assessment tests are the basis of self-directed learning. Therefore, the purpose of this research is to determine the use of various e-study materials in the learning of a mathematics course, as well as the importance of tests in the self-assessment of mathematical knowledge and skills. The findings of this study include the analysis of the usage of e-study materials and tests for assessing students' mathematical knowledge and skills, as well as determination of the importance of self-assessment tests in the learning of a mathematics course, based on the students' opinion.

1. INTRODUCTION

At present, issues of the education system and quality improvement are topical in the whole world. Today, universities need to be prepared to offer young people education that makes them competitive in these new working conditions. When considering development of the education, they shall understand necessity of changing both content and form of the studies. As today's youth grow in an era of digital technologies and is dwelling in a virtual environment, they increasingly are demanding flexible study format that complies with their usual habitat. Therefore, the main task of universities and other higher educational establishments at this time of change is to develop intellectual skills, exploratory research attitudes and build information and communication technologies (ICT) skills in a new specialist. As result, nowadays information and communication technologies are increasingly being used in higher education and training (Crampton et al, 2010).

At a time when is talked about the quality of universities and its improvement, two of Latvia's largest technical universities: Latvia University of Life Sciences and Technologies and Riga Technical University use e-study systems based on the Modular Object-Oriented Dynamic Learning Environment (MOODLE) e-learning platform. The e-study system makes the life of every student easier, as long as he wants to make his learning process more efficient, modern and faster. With the e-study system, university studies can be accessed from anywhere and at any time.

Each subject has a separate section, where it is possible to cooperate with both fellow students and teaching staff and learn about the issues related to learning the course and, of course, to use the e-study environment to learn the content of the relevant course. The teacher of each course offers students a variety of opportunities to study independently and prepare for exams.

The mathematical learning environment is also influenced by the development of information technology (Galbraith & Haines, 1998). Information communication technologies are used also in the mathematics studies of both universities to independently learn the available informative and interactive e-materials, solve tasks with mathematics software, find the necessary information, collaborate online, etc. In both universities, the e-study environment contains various learning materials that were used as a supplement to full-time mathematics studies, organizing students' independent work, evaluating knowledge and skills, as well as communication between students and teachers, keeping track of grades and test results, list of lessons or other changes etc. (Vintere et al, 2022).

Although ICT has been an important part of higher education for a long time, it was crucial during remote studies, when students had to put more effort to decide and choose what to focus on, identify things that are successful and areas that might need a little more work. This type of responsibility for one's education is characterized by self-directed learning (Vintere et al, 2021). Self-learning is an important part of higher education both in the context of the fourth industrial revolution and sustainable development (Briede, 2019). To increase students' responsibility for the learning process and to promote the ability to independently acquire knowledge, skills and abilities, it is necessary to create the preconditions for self-directed learning in higher education institutions, that is, students themselves participating in setting the purpose of studies, planning the acquisition of the subject and evaluating their work and the progress of studies. The purpose of this research is to determine the use of various e-study materials in the learning of a mathematics course, as well as the importance of tests in the self-assessment of mathematical knowledge and skills.

2. MATERIALS AND METHODS

The information provided by the MOODLE system was used for this study, regarding the students' activities during the mathematics courses taught by the authors of this article, as well as the results of student surveys. Another functionality offered by the e-system of both universities is obtaining student feedback through surveys, which are conducted at least once a semester. Internet survey is one of the most modern and advanced research methods. This is also one of the most commonly used research methods. An objective opinion on the question of interest can be obtained by clearly and precisely defining the points of the questionnaire and selecting certain respondents.

The obtained data are essential for improving the quality of studies. After careful evaluation of the collected data, decisions are usually made to improve the quality of mathematics teaching. This study also uses the results of a student survey on the importance of self-assessment tests in the learning of a mathematics course.

According to educational research, the "self-assessment is a process during which students collect information about their own performance or progress; compare it to explicitly stated criteria, goals, or standards; and revise accordingly. Self-assessment method is seen as the most powerful means for a tertiary education organisation to understand and improve its performance. The purposes of self-assessment are to identify areas of strength and weakness in one's work to make improvements and promote learning" (Andrade & Valtcheva, 2009). Therefore, the research used the self-assessment method in two senses:

1) tests for self-assessment of students' mathematics course knowledge and skills;
2) students' opinion about the importance of self-assessment tests in learning mathematics.

3. FINDINGS

The findings include the analysis of the usage of e-study materials and tests for assessing students' mathematical knowledge and skills, as well as determination of the importance of self-assessment tests in the learning of a mathematics course, based on the students' opinion.

3.1 The Usage of e-Study Materials by Students

The results of the study confirm the well-known fact that students' activity in the e-study system increases mainly before the examination period.

In the framework of this study, information on the use of various e-study materials in the 1st and 2nd semesters has been collected. As indicate results in Table 1, the assessments obtained represent the top interest of students. The examples of tasks solutions and lecture notes are the most used teaching aids, whereas students show a little interest about informative materials like syllabus, requirements for successful completion of a subject, examination requirements and sources of literature.

Table 1. Number of views of different e-study materials

	1st semester	2nd semester	During lockdown
Informative materials	3.6%	2.2%	38%
Lecture notes	14.5%	12.7%	80%
Samples of problem solving	15.4%	19.2%	72%
Descriptions of laboratory work	13.2%	11.0%	-
Formulas	5.2%	11.5%	20%
Tasks for independent work	7.5%	10.0%	18%
Self-assessment tests	12.2%	5.3%	22%
Assessments obtained	28.4%	28.1%	-

Comparing student activities during the two semesters, it should be concluded that in the 1st semester, lecture notes, descriptions of laboratory work, as well as self-assessment tests of knowledge and skills are used more. In the 2nd semester, the focus of students is more on problem solving samples, and various formulas are used more, which can be explained by the fact that the study content of the 2nd semester includes derivatives and integral calculus.

As known, due to the Covid-19 lockdown, studies in all universities were organized remotely, causing a series of challenges that are usually not relevant in a face-to-face learning environment. This, of course, also changed students' habits of using e-study system and learning materials, which it contains. As seen in Table 1, very rapidly increased the usage of lecture notes, samples of problem solving as well as usage of other informative materials. During that time lectures were given on Zoom or another video-conferencing platform, where a teacher wrote and explained the course content step by step and solves practical exercises. Video recording of theses lectures were used by students very often. It should be noted that laboratory works were not organized during lockdown, as both universities are using commercial software MATLAB.

3.2 Tests for Assessing Students' Mathematical Knowledge and Skills

Compilation of tests for the students' knowledge assessment is the most used one out of multiple e-studies functionalities. The evaluation of student knowledge through online testing is a relatively new method for assessing and checking knowledge. It provides ample opportunities for modernizing and optimizing the learning process. However, the attitude towards assessing the level of knowledge through tests is still unclear. Reasonable question arises: does testing produce objective results? Because of this, it must be said that today's tests are significantly different from those used a few years ago. Test theory is one of the directions in the science of pedagogy, which is rapidly developing. Adherence to the basic laws of this theory allows for the development of test systems that can be effectively used at different stages of the learning process.

Literature (Dunlosky et al, 2013) describes in detail 10 key teaching methods and evaluates their relative usefulness. Student testing is referred to as one of the main methods and has received a high-performance appraisal.

As usual, new ideas, trends and methods generate controversy. Although the use of tests can only be considered a relatively new method, polar opposite testimonials of tests, their usefulness and the objectivity of knowledge assessment can still be heard. Sometimes the same arguments sound from both sides i.e. from those who are for and from those who are against knowledge testing.

Arguments against:
- tests lower the role of the teacher;
- tests do not allow to comprehensively assess the knowledge, its depth, etc.

Arguments in favour:
- tests reduce the capacity of the study process;
- tests allow you to objectively assess the knowledge to be tested, etc.

This article attempts to answer the question: "Does testing really give objective results and what to do to obtain them?" Testing itself most often does not cause any significant problems. Important parts of this process are:

1) The determination of the goals to be tested;
2) The choice of the correct type of questions;
3) The exact wording of the question;
4) The evaluation and interpretation of test results.

The goals we want to achieve through these tests must be set before the start of the test (Appleby et al, 1997). If there are several goals, their importance should be determined, the non-essential objectives should be discarded, and the same number of questions should be drawn for each important objective.

When selecting the type of questions, it must be considered that the author of the choice questions (these are questions that ask students to choose the answer from the proposed options) should anticipate possible mistakes. It is therefore better to choose the questions students can answer themselves. The question should be short and clearly worded, simple, easy to understand. The question must not pose problems for the student; it must be done in a way so that the student can answer it using a textbook, remembering facts and algorithms (Boesen et al 2010). Better yet, if questions can be compiled in such a way as to test intermediate results and track errors (Seeman, 2015).

The evaluation and interpretation of results is also an essential part of testing, since without a comprehensive evaluation of the results it is impossible to conclude what needs to be addressed in the future, how to improve the learning methods and the quality of the study process. The mathematical and statistical methods that make it possible to efficiently use computer hardware at this stage and thus to automate and optimize the tasks foreseen are widely used for the evaluation of test results.

In recent years, the authors have collected and implemented a series of tests in the e-study environment, which serve as an important self-assessment tool and help students to improve their mathematical competences.

The results of the mathematics course tests during the 1st semester discussed below (Table 2): the first column - the average rating for the first attempts, the second column - the average rating for the last attempt, the third - the average rating for the best attempt.

Table 2. Number of views of different e-study materials

	First attempt	Last attempt	Best attempt
Determinants	82%	97%	97%
Operations with matrices	63%	80%	81%
Systems of linear equations	65%	80%	82%
Linear operations on vectors and dot product	55%	61%	62%
Cross product and mixed product of vectors Straight line in a plane	66%	79%	80%
Analytic geometry in three-dimensional space	49%	67%	69%
Limits	52%	68%	69%
Differential calculus of a function of one variable	78%	82%	83%
Extrema of functions. inflection points and asymptotes of a function	71%	83%	85%

Taking all the test ratings together, we get the following results: 63.83% average in the first attempt, 65.98% in all attempts, 79.84% - in the final and 81.69% - in the best attempt. From the Table 2 can be concluded that often the first attempt is not the most successful, while the last attempt is mostly the best. The best results were obtained in the test "Determinants" and the test "Limits", while the worst results are in both Analytical Geometry tests - "Straight line in a plane" and "Analytic geometry in three-dimensional space".

Comparing the number of students who completed the test at least once and - the number of total attempts, it should be noted that the number of students who completed the tests is decreasing on 41%. There are two reasons for this: first, some students leave university in the middle of the 1st year, secondly, students grow tired by the end of the term and perform less of the tasks and tests.

3.3 Tests for Assessing Students' Mathematical Knowledge

Comparing the number of students with the maximum score to the number of students who completed the test (Table 3), we see that in nine of the tests, more than half of the students gave the perfectly correct answer, while in the three tests, the correct answers were given by less than half of the students. Of course, this has an impact on the study results.

Table 3. Number of students (%) who received the maximum score

	First attempt
Determinants	92%
Operations with matrices	59%
Systems of linear equations	58%
Linear operations on vectors and dot product	33%
Cross product and mixed product of vectors Straight line in a plane	46%
Analytic geometry in three-dimensional space	41%
Limits	74%
Differential calculus of a function of one variable	63%
Extrema of functions. inflection points and asymptotes of a function	58%

Considering the specifics of the mathematics subject (notes of mathematical relations, drawings, formulas, etc.), the preparation and adaptation of self-assessment tests to the e-study system is a very labor-intensive process and requires a lot of effort from teachers. Despite this, self-assessment tests play a decisive role in ensuring self-directed studies and promoting competence, which results from the development trends of society. Self-assessment tests are also highly valued by students.

The survey results show, that most of the students consider that even self-assessment tests are needed, as they help master the material, learn from mistakes and be better prepared for the exam, etc. (Table 4).

Table 4. Students' opinion about the self-assessment tests

	First attempt
Help to be better prepared for exam	43%
Help better understand the topics and to learn from mistakes	63%
Had a significant impact on the final grade	15%
Helped to understand the tasks of the independent works	34%
Contributed to the motivation to learn mathematics	26%

4. CONCLUSION

Not all learning materials in e-studies are used by students. Only about one fifth of students regularly use problem solving samples. A summary of grades and assessment obtained is usually a resource of primary interest to students, which leads to the conclusion that the e-study system serves mainly the so-called non-learning activities.

During the Covid-19 lockdown, remote studies changed the habits of students to use the e-study system and the learning materials contained in it, with a very rapid increase in interest in lecture notes and video recordings, as well as problem solving samples. This means that in order to increase students' responsibility for the learning process and promote the ability to independently acquire knowledge, skills and abilities, it is necessary to create stricter prerequisites for self-learning in universities.

Results show, that self-assessment tests play a decisive role in ensuring self-directed studies and promoting self-competence development. Self-assessment tests are also highly valued by students in achieving mathematics course study results.

When the outcome of data of self-assessment tests had been compared with the final course results, there could be observed a correlation: generally, students who show good results in the self-assessment tests are successful at other assessment tests, including exam.

As the study mainly used the self-assessment method, so the results were based on the opinion of the respondents and therefore the results cannot be generalized, but can be used to identify problems and identify future actions or research directions.

REFERENCES

Andrade H. and Valtcheva A., 2009. Promoting learning and achievement through self-assessment. Theory into Practice, 48, pp. 12-19.

Appleby J. et al, 1997. Diagnosys - a knowledge-based diagnostic test of basic mathematical skills. Computers & Education, 28(2), 113-131.

Boesen et al, 2010. The Relation between Types of Assessment Tasks and the Mathematical Reasoning Students Use. Educational Studies in Mathematics 75, no. 1, pp. 89–105. Crampton A. et al, 2010.Vodcasts! How to unsuccessfully implement a new online tool. *Interaction in Communication Technologies and Virtual Learning Environments: Human Factors*, pp. 118-128.

Briede B., 2019, Students' self-directed learning in the context of industrial challenges: Latvia University of Life Sciences and Technologies case. Proceeding of 5th International Conference on Higher Education Advances (HEAd'19) Valencia. Spain, June 26-28, 2019, pp. 685.-694.

Dunlosky J. et al, 2013. Improving students' learning with effective learning techniques: Promising directions from cognitive and educational psychology. Psychological Science in the Public Interest, 14(1), 4–58.

Galbraith P. and Haines C., 1998. Disentangling the nexus: Attitudes to mathematics and technology in a computer learning environment. *Educational Studies in Mathematics,* 36, 275-290.

Seemann E., 2015. Unit Testing Maths. In: Conole, G., Klobučar, T., Rensing, C., Konert, J., Lavoué, E. (eds) Design for Teaching and Learning in a Networked World. EC-TEL 2015. Lecture Notes in Computer Science(), vol 9307. Springer, Cham.

Vintere A., et al, 2022, A comparative study of the organization of a remote mathematics study process during the Covid-19 pandemic. *Mobility for Smart Cities and Regional Development - Challenges for Higher Education: proceedings of the 24th International conference on Interactive Collaborative Learning (ICL2021).* Technische Universität Dresden, India : Springer Nature, 2022, pp. 7631-7636.

Vintere A. et al, 2021, Challenges and benefits of remote learning in context of competence development of engineering students during Covid-19 pandemic. *20th International scientific conference "Engineering for rural development" :proceedings.* Jelgava, Vol. 20, pp. 1663-1671.