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Improved learning environment for calculus courses

László Bognár[a], Hamar Éva Fáncsikné[b], Péter Horváth[c], Antal Joós[d], Bálint Nagy[e], Györgyi Strauber[f]

University of Dunaújváros, Táncsics M. u 1/A, Dunaújváros 2400, Hungary, [a]drbognar@gmail.com, [b]fancsikne@uniduna.hu, [c]horvathp@uniduna.hu, [d]joosanti@gmail.com, [e]nagyb@uniduna.hu [f]strauber@uniduna.hu

Abstract

The Department of Mathematics of the University of Dunaújváros is devoted to the success of their students. It results in a deep understanding of the students' needs. Appropriate course material including video lectures, notes, handbook, practice tests, detailed study guide, consultations personally and via email, chat using social networks make this approach fruitful. Modern learning methods are also introduced. Several studies show that changing the learning environment (LE) of higher education courses increases student success. In this work the improvement of the LE applied for the Mathematics course of the University of Dunaújváros is introduced. Using this LE the education is much more effective than in the traditional ways.

*Keywords:*teaching mathematics; education; learning environment;

1. Introduction

In 2000, College of Dunaújváros (later University of Applied Sciences of Dunaújváros, DUE) was the newest undergraduate institution in Hungary with about 4000 students. Mathematics courses were given in a traditional lecture format and direct teaching was applied. Students come to class, listen to lectures and then they were expected to do tasks to demonstrate their knowledge.

Educational methods usually applied in the higher education are presentation, explanation, discussion, debate, demonstration, learning by doing method, project method, cooperative educational method, simulation, roleplay and game, study trips, home assignment. (Howeversimulation, roleplay and game, study trips frequently cease to exist on maths courses.) Other methodologies and other formalism of calculus were available worldwide, that is opposed to the standard approach of Weierstrass, teaching calculus with infinitesimals were introduced. (Hernández, L. M., Fernández, J. M. L. 2018). Furthermore, some universities implemented computer labs using a Computer Algebra System (CAS) evaluating hybrid teaching to foster interactivity and facilitate a more personalized work with the students. The appropriate CAS was hard to identify. Often Mathematica, Matlab, Maple or even Derive was the chosen software. Nowadays GeoGebra or Octave seems to be good candidates also. (León de la Barra et al. 1999).

2. Developing the course

It is increasingly difficult to maintain student interest for a long period of time. Multimedia technology is considered as a useful tool that can capture the attention of today's students. Teaching with the hybrid-format (Young, 2002) or blended learning combines the typical traditional course components (lectures and in-class activities) with some online course component providing flexibility. Students complete learning activities online and in the class synchronously (Kerres, M., DeWitt, C. 2003).

Several articles compared the hybrid method and face to face method in teaching Mathematics and other subjects. It is found that "students taught by the hybrid method were able to participate actively in the duration of the course" and they achieved better grades. (Lacatan, 2013)

It is also shown that mathematics courses strengthen the soft skills of students. A multivariable calculus course covering functions of several variables, partial derivatives, multiple integrals, vector functions, and vector calculus were taught over a period of 14 weeks with 2 hours face-to-face and a 1-hour laboratory session by blended learning methods. Students activities consists of working in a small group, critical thinking and problem solving, doing assignments, reading and writing. "Results indicated that the blended learning multivariable calculus course has positive effects on students' communication skills." (Kashefi et al., 2012)

Later open source and free online courses were also developed to provide high-quality calculus.

This open source material can be modified to meet the needs of other instructors. (Korey, 2007).

In 2000 Calculus lectures and practice lessons were available for the students at DUE. In the lecture session, the mathematical concepts were introduced to the whole class. After the students had established a general idea of the concept, they then proceeded to the practice session. In the practice session, students were directed to perform mathematics tasks.

The first course in the scope of this work is Precalculus. On DUE this course is not an obligatory course, but available for volunteer students if it is needed. The aim of the Precalculus course is developing and deepening problem-solving ability as well as mathematical background needed prior to higher level mathematics courses. The prerequisites of the course are secondary school mathematics. The applied method is direct teaching in small groups, solving computational and applied exercises using projector, blackboard, calculators, and computers. Finishing this semester, the students know the mathematical background required to perform higher level mathematics courses and they are ready to understand and solve mathematical exercises and problems emerging in their field of science. Students should take responsibility for their own work. There is a considerable amount of material to be covered because the content of the course includes algebra concepts, integral exponents, radicals and rational exponents, operations with rational exponents, factoring, algebraic fractions, the solution of linear equations and inequalities of one variable, systems of equations, linear functions and their applications, quadratic functions, logarithmic functions, logarithmic equations and inequalities and plane trigonometry.

Usual activities are learning of the theory and solving mathematical exercises with direction and without direction using pattern and examples. They use traditional books, e-books, hyperlinked documents and other sources from the internet. During the semester there are three compulsory tests: one (maximum 30 points) on the 3rd week, the second (maximum 40 points) on the 7th week, and the third (maximum 30 points) on the 12th week. The tests consist of questions on applied problems. The students may make up the three tests on the 13th week.

The obligatory course in Calculus is Engineering mathematics 1 and 3 (Two semesters are given for basic Calculus).

In these courses, mathematical theory is introduced to solve quantitative problems in technical and other fields. On the lectures notions and methods are introduced in a lecture hall, using blackboard. Practice lessons or seminars and computer labs are taught in small groups, solving computational and applied exercises. The course requirements include knowing basics mathematical background and theoretical concepts and knowledge and understanding of the concepts needed in further studies. Basics in applying a computer algebra system is also a must.

The contents of the first course are the following: Set-theoretical background. Functions of one variable. Basic properties of functions of one variable. Limits of functions and sequences. Differential calculus of functions of one variable. Differentiation rules. Mean value theorems. Applications of derivatives. Integral calculus of functions of one variable. The definite integral. The indefinite integral and its properties. Basic properties of functions of several variables. Differential calculus of functions of several variables. The Mathematics 3 course is the last Calculus course on DUE. It consists of the following topics: Special differentiation rules. Geometric application of derivatives. Area. Volumes and surfaces of revolution. Length of a curve. Centre of gravity. Multiple integration. Numerical integration. Solving nonlinear equations. Separable differential equations. Variable transformation: ax+by+c. Variable transformation: y/x. First order linear differential equations. Second order linear differential equations. Missing variable in second order differential equations.

In 2012 DUE developed maths and other courses as well. Calculus was developed and implemented in the Moodle as a course management system to increase student success.

The courses are built from video-driven mini-topics. Each mini topic has an introductory video and one to three questions after the video, as can be seen onthe icons of Fig. 1. The content of the course can be found onthe left side of the screen. On Fig 1. from the chapter “Special differentiation rules”the subsection “Logarithmic differentiation” is chosen. In this section four media content is available. The content can be chosen from the icons visible on the top of the screen: A short video introducing the method itself, notes for this section in pdf form and the appropriate chapter of the handbook. At the end of this mini-topic a multiple-choice test is to be solved. This problem is similarto the one solved in the video. In this chapter section 1.2, 1.3 and 1.4 is also can be studied. Section 1.5 consist of a test including selected problems from this chapter. A homework also can be found in this section.

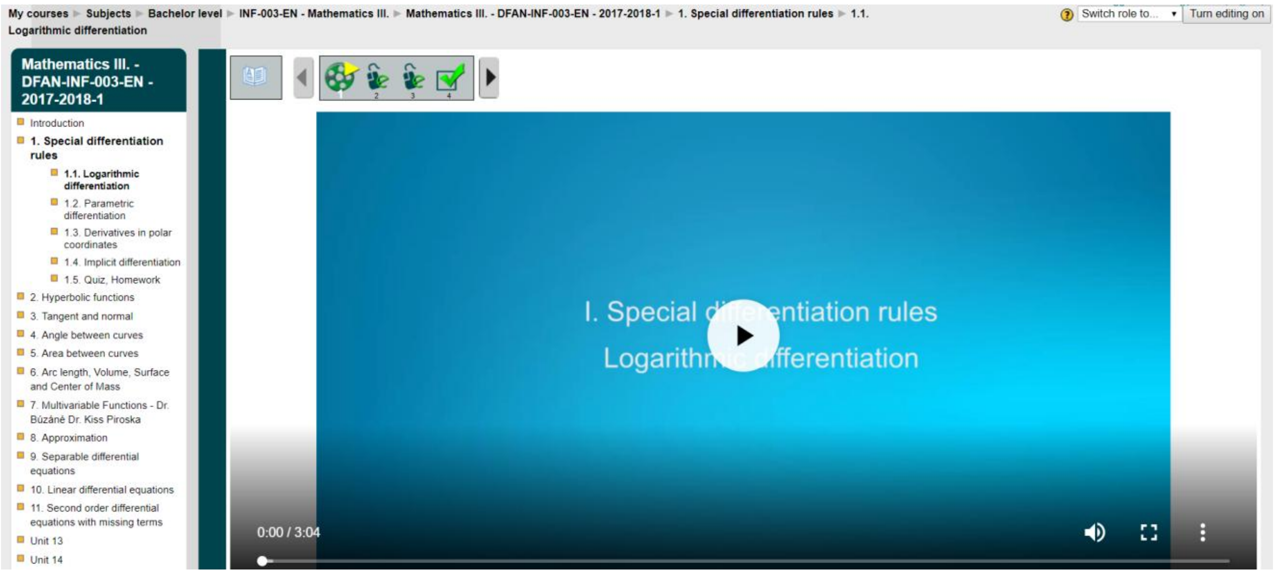

Fig. 1. The Mathematics course in the Moodle system.

Students should answer these multiple-choice tests correctly. A sample can be seen on Fig. 2. Automatic feedback for students is given. These courses are applied in distance learning, although the course material is available for the full-time students as well.

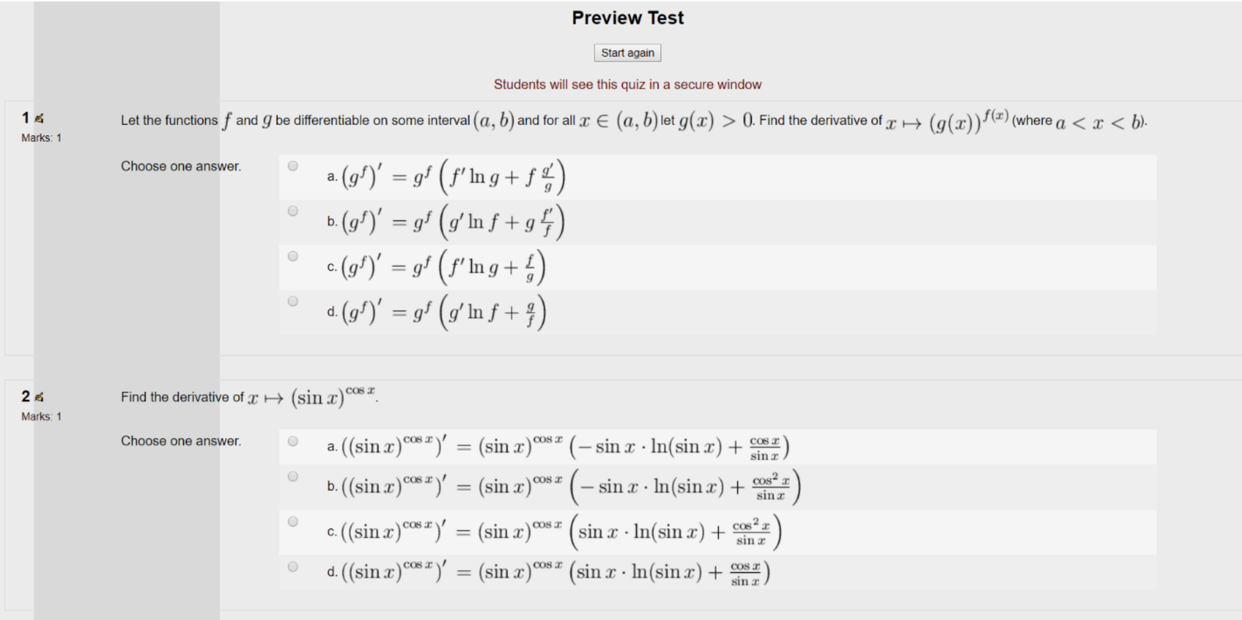

Fig. 2. Sample multiple-choice test for the Mathematics III course in the Moodle system.

Student attrition has been a continual topic of concern in distance education research. There have been some research explicitly studying the preferences for (asynchronous) online courses versus traditional classroom courses.

Drop rates for distance classes have been consistently higher than those of traditional classes (Cookson 1990). In fact, many educators have implied that the high drop rates—and the resulting lower success rates—of such courses should disqualify online education as a high-quality option to traditional education (Perspective 2001). However large studies have been conducted to compare the effectiveness of the different forms of course delivery and to establish key factors to build up successful online courses with relatively low drop rates (The NMC Horizon Report: 2012).

The reasons for students' attrition have been intensively investigated.

Four categories of factors have emerged to explain and predict attrition in distance education (Garland 1993; Gibson 1998):

Student situation: events that arise from life circumstances such as changes in family and employer support, employment or financial status, educational status, health, and academic self-concept.

Student disposition: personal characteristics including learning style, motivation, and perception-of-obligation (i.e., feelings of being obligated to a specific instructor or classmates to remain enrolled in the class) as well as other demographic variables such as academic preparation, GPA, ethnicity, gender, Web and e-mail competency, family size, number of dependents, and socio-economic status.

Institutional system: factors relating to the quality of the course such as the instructor's planning, preparation and delivery, and the quality of student support provided by the instructor, another faculty, staff, administrators, and the institution.

Course content: the difficulty, or perceived difficulty, of the subject matter.

Diaz (Diaz 2002) noted that given the differences in populations, online students may drop for different reasons than traditional students and that those reasons may have little or no relationship to students' academic abilities.

Although there have been few research explicitly studying the preferences for online courses versus traditional classroom courses, there have been several investigations of students' preferences for important components of these formats, namely face-to-face interactions and asynchronous discussions. Support for the idea that students would prefer, and learn more from, face-to-face communications comes from a variety of theoretical perspectives including social presence (Short, Williams, & Christie, 1976), media naturalness (Kock, Verville, & Garza, 2007), and especially, media richness (Daft & Lengel, 1986). Media richness theory suggests several advantages of face-to-face communications including body language, auditory cues, other non-verbal cues, and immediacy of feedback.

There has been a lack of research studying the factors – known or unknown to the students – which affect their preferences in choosing the different course formats. Statistical methods have been applied to establish those features of the students which might influence their choices between the different versions of teaching and learning.

As can be expected the ages, ICT skills of students influence their choice. Their attitude to learning (based on their self-evaluations) severely affect their choice too. The "lazier" they regard themselves the larger the chance to choose the online video lessons instead of the classroom work.

3. Introducing virtual learning environments

In 2017 improving the learning spaces in Moodle was decided on DUE.Virtual reality is widely used in medicine (Riener R, Harders M., 2012), education (Horváth 2016) and many other fields (Galambos et al. 2010; Baranyi et al., 2015; Gilányi et al., 2017.; Ujbanyi et al. 2016; Varaljai, 2016). Considering that the 3D visualization applied in the virtual reality (VR) learning environment better suits the cognitive processes of the human brain, MaxWhere, a 3D environment engine available is applied.

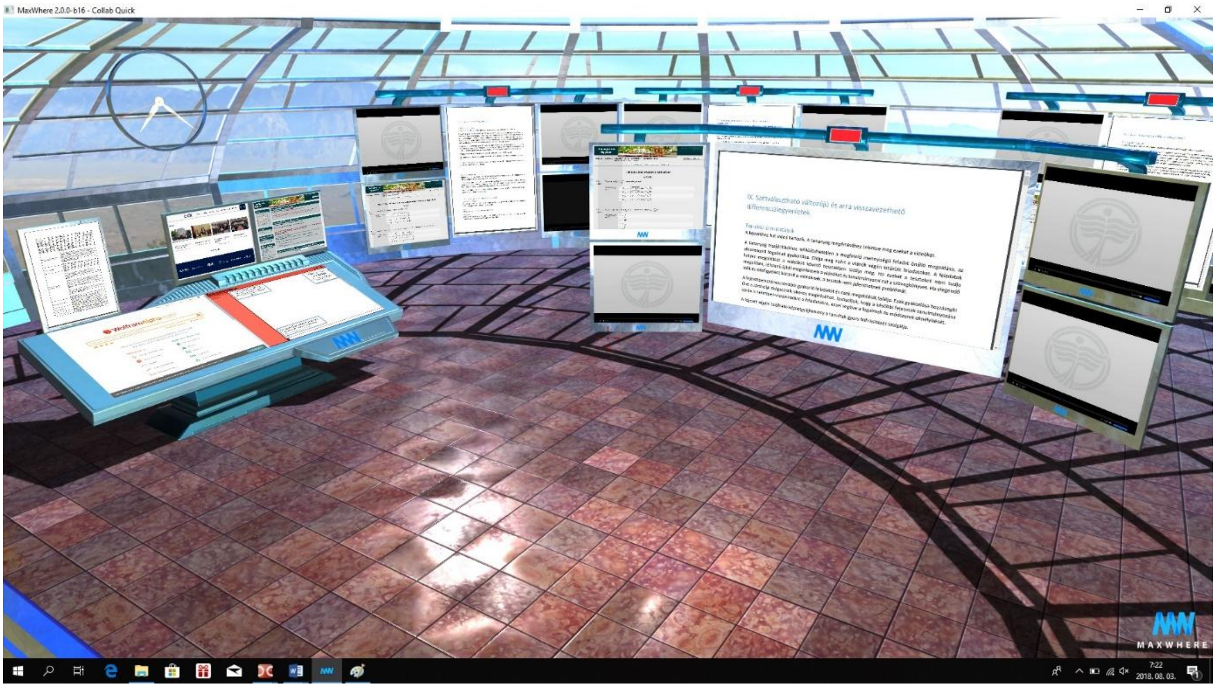

Fig. 3. Learning contents in MaxWhere

The contents of the course are very similar to the Moodle version, but it is found, that the 3D environment is much more effective than traditional techniques (Horvath, I.,Sudar, A.2018).

The course content is implemented in the CollabQucik space. There are 4 midterms in a semester and a space with the learning material of each midterm is available for the students, see Fig. 3.

In what follows the learning environment for the first midterm in details is considered, because the other spaces are very similar to this. The content of this midterm is special differentiation rules and application of calculus. In the middle of the space, a smartboard with five windows can be seen. The web page of the DUE, the Moodle, the course content, WolframAlpha and online Octave is available here. There are six other group of smartboards in this space. These include a variety of learning contents. In the first group, one smartboard in the middle and four other smartboards around this can be seen. The content of this group is special differentiation rules. On the middle board, a book chapter on logarithmic differentiation method is introduced using an example. This example can be found as a 3 min video on the smartboard in the upper right corner. In the upper left corner, a Moodle page is available with the appropriate multiple-choice tests. Students should first study the book chapter and the video lectures. After getting some insight into the method itself they should solve the problems in the video and answer the questions in the Moodle window. Solving the problems, they can have an automatic feedback on their understanding.

4. Conclusions

A survey was conducted to investigate the attitude of students towards electronic learning materials of University of Dunaújváros. It is concluded that the students have a positive attitude towards the virtual LE although the detailed analysis of the survey is to be published in another article. It appears that 3D learning environment is suitable for many students, however the efficiency of this method depends on the technological background the students have. The MaxWhere 3D learning environment was found to be a useful tool for mathematics education.

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Short professional biography

László Bognár is full professor at the University of Applied Sciences of Dunaújváros. His special fields are the random vibration and different topics in Applied Statistics. He published several articles on engineering application of random processes.

Eva Fancsikne Hamar is a lecturer at the University of Applied Sciences of Dunaújváros. She is an expert of Mathematical Geophysics.

Peter Horvath is a lecturer at the University of Applied Sciences of Dunaújváros. His mqain research field is the education of mathematics.

Antal Joós is a full professor at the Department of Mathematics of University of Applied Sciences of Dunaújváros. His main research fields are discrete and convex geometry. The year of his first article is 2007.

Balint Nagy is full professor at the University of Applied Sciences of Dunaújváros, head of the Department of Mathematics. His main research fields are qualitative theory of differential equations, bifurcations of biological models and education of mathematics. He is the author of numerous articles in academic journals.

Györgyi Strauber is a professor at the University of Applied Sciences of Dunaújváros. Her main research field is numerical mathematics.