

PRZEMYSŁAW OSOCHA\*

## THE EFFECTIVENESS OF E-LEARNING IN ENGINEERING EDUCATION

### EFEKTYWNOŚĆ E-LEARNINGU W EDUKACJI INŻYNIERSKIEJ

#### Abstract

Changes in technology, availability of video casts and the general increase of information and knowledge value result in the advent of educational technology. As the first step toward validation of the effectiveness of e-learning in engineering education, a research on a group of students was carried out. The open-source and free software educational platform Moodle was used to conduct a selected course in the form of blended e-learning. The course was prepared and presented to the students during one semester time period. The effects of learning were verified through knowledge tests and their results were collected for analysis. Students in the test group achieved results equal or even better than other groups, validating the effectiveness of e-learning in engineering education. During the experiment also other positive aspects of e-learning were noted: students appreciated freedom of time and place where they learn and for the teacher high effort connected with course preparation could be rewarded by multiple use of the developed course at a later time.

*Keywords: e-learning, collaborative systems, technology enhanced learning, smart university*

#### Streszczenie

Zmiany technologiczne, dostępność wideotransmisji i ogólny wzrost wartości informacji i wiedzy doprowadziły do rozkwitu technologii edukacyjnych. Pierwszym krokiem w kierunku walidacji efektywności e-learningu w nauczaniu inżynierskim było przeprowadzenie badań na grupie studentów. Darmowa i otwarta platforma edukacyjna Moodle została użyta do przeprowadzenia wybranego kursu w formie mieszanego e-learningu. Kurs został przygotowany i przedstawiony studentom w czasie jednego semestru nauki. Efekty kształcenia były weryfikowane za pomocą testów wiedzy, a ich wyniki zbierano do dalszej analizy. Studenci w grupach testowych osiągnęli wyniki nie gorsze niż w innych grupach, potwierdzając tym samym efektywność e-learningu w nauczaniu inżynierskim. Podczas eksperymentu dostrzeżone zostały także inne pozytywne aspekty e-learningu: studenci doceniali swobodę czasu i miejsca gdzie mogą się uczyć, a wykładowcy dostrzegli, że duży nakład pracy poświęcony na przygotowanie kursu może zostać zrekompensowany przez późniejsze jego wielokrotne użycie.

*Słowa kluczowe: e-learning, systemy współpracy, nauka wspomagana technologią, inteligentna uczelnia*

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\* Ph.D. Przemysław Osocha, Institute of Applied Informatics, Faculty of Mechanical Engineering, Cracow University of Technology.

## 1. Introduction

In the last decades we have witnessed enormous development and growth in the electronic technology market. Electronic devices are getting smaller, more powerful and are pervasively blending into human environment. The ubiquitous connectivity of all kinds of devices through wired or wireless networks which utilizes numerous communication standards is even more important for this process of irrepressible spreading than the small form factor and raising computational power. Examples of such devices in personal service include smart TV sets, laptops, tablets, smartphones, smartwatches, together with all the wired and wireless infrastructure providing connectivity. Those changes impact most of the human life areas: how we work, how we rest and entertain and also how we learn.

The raise of mobility of electronic devices and significant increase of data transfer bandwidth are the main game changers for educational technology advent. E-learning is not limited anymore to plain text as educational data maybe presented in the form of high quality videos as well as sound and interactive advanced demonstrations.

On the other hand, there is a raising appetite in our population to consume more and more information. Manual labor loses its importance in favor of knowledge. People of all ages are looking for opportunities to leverage their education to a higher level. And this is where technical informational revolution and human needs meet together in the form of educational technology [1].

There is a number of e-learning definitions and approaches; even learning by means of an electronic device like calculator can be called e-learning. However, let us stick to the well accepted definition where e-learning is online distance learning [2, 3]. And it is worth mentioning that there are some variants of e-learning, e.g. hybrid or blended learning, where traditional stationary learning is reduced but not eliminated, and is replaced with some e-learning. Looking back in history, one of the first examples of e-learning, as we understand it today, is a system introduced by the University of Illinois in 1960, where informational resources were provided by computer terminals together with recorded lectures available by remotely linked television or audio devices. In the mid-1980s, many college libraries already offered courses in the electronic form. But the real dawn of online distant learning was a solution provided by the Open University in Britain and the University of British Columbia which used the Internet to deliver web-based trainings and online discussions for students. In 2003, the number of students using e-learning reached 1.9 million mark, and started to increase by 25% every year. Nowadays most of educational institutions offer some form of e-learning for their students. The Council of Europe endorsed in 2008 a statement that e-learning has potential to drive equality and education improvements in the whole European Union. Nowadays higher education in Poland is looking for possibilities to lower costs of the teaching process. The introduction of e-learning could be not only an economic solution, but in fact a way to spread the wings by attracting even more students and leaving to personnel of the university more time for research work. The goal of this paper is to present and analyse the introduction of e-learning in one course of engineering studies.

## 2. Materials and Methods

Moodle is a leading, free and open-source e-learning platform used for blended learning and distance education in schools, universities and for corporate and private websites with online courses and trainings [4]. The system is written in the PHP language and distributed under the General Public License (GNU). Moodle uses pedagogical approach to learning and incorporates a number of features like calendars, gradebooks and plugins system which extend it even more. Customizable themes, often based on the responsive web design, allow courses to be used also on mobile devices. The Cracow University of Technology uses Moodle as its official e-learning platform for students [5]. It is called ELF for e-learning framework. All students who start studies at the university are required to create an account in that e-learning system. The current version of Moodle in use at that platform is 2.5.2.

The Moodle software provides teachers with numerous options of how to implement the learning process. From that wide range of possibilities, a subset of core functionalities was selected. One of the most popular way of providing the content in the last years is video transmission. It is easily observable how the Youtube service has gained popularity worldwide, and how many similar services have emerged in the last decade. This phenomenon of ubiquitous online video casting through the Internet was only possible thanks to the technology progress, especially in electronic miniaturization and wide band data transmission.

## 3. Results

The selected course was to some extent implemented in the form of e-learning. The course subject “Algorithms and Data Structures” is one of the basic courses for applied informatics students. It was taught in the form of lectures and computer laboratories. The lectures and in some part laboratories were implemented in the form of e-learning system. As a base for the electronic version of the course, an official e-learning platform of the Cracow University of Technology was used. The platform [elf2.pk.edu.pl](http://elf2.pk.edu.pl) is based on the open source software called Moodle. The first lecture was provided in a blended form, both live in the classroom and also in the electronic version for a later review by students. At the first meeting, except for the first part of the course, students were informed about the aim, range and requirements of the course, the e-learning platform was presented and, what is important, they had the opportunity to meet their teacher in person.

There is a number of ways to register to the e-learning course, ranging from teacher registering every student individually to a fully open course where every student may attend at his will. In the case of the discussed course, students obtained registration key per students group and registered themselves. In this way, there was less work for the teacher, and later it was easy to sort students by student group for final classification. It is worth mentioning that all students at the university already have verified accounts in the official learning platform, so there is little probability of an unwanted person getting access to course materials. Furthermore, before opening access to the materials, the teacher verifies registered students and closes registration for the course. The material of the course is presented to

students in parts available in defined time periods, similar to the life course where meetings are every one or two weeks. This method builds in students systematic approach to learning. Students can memorize better and understand every part of the lesson, because they are not overwhelmed by the availability of all the course material at once, since sections of the course are published in parts in defined time frames. On the other hand, students are not overloaded with too much data at the end of the course, since every part of the course ends with a test that has to be timely solved, making it impossible to learn in an unsystematic way.

Every section of learning material is composed of a lecture in the form of a video screencast and a corresponding PDF file containing presentations slides, together with a selection test verifying understanding of the provided courseware.

The most attractive part of the course is a video of the lecture. It is only possible to provide content in that form due to massive advances in electronic and connectivity technologies made in the last years. Videos presented in the course are screencasts of MS Power Point presentation, together with the recorded voice of a lecturer. Drawings and notes made live in the presentation with the stylus of a PC computer are an important part of the teaching process. It is possible due to the use of tablet computers with a stylus and digitizer screen. This way the lecturer may highlight important parts of the slide, draw additional pictures or write additional explanatory texts on the screen.

It is important that a video may be played not only on the computer, but on any device equipped with a web browser, at any time and in almost any place.

Students may freely review and download slides from presentations in the PDF format. It allows them to review the lecture material, make notes or print out for a later use. During video playback students concentrate on the presented material, knowing that slides are available for a later review.

Every section of teaching materials ends with a selections test verifying if the presented lecture was actually reviewed and well understood by students. The test is a set of 5 questions randomly selected from about 20 questions prepared for a particular section. Every question may have multiple correct answers, so it is possible that there is only one correct answer, two or three correct answers, or even all the answers may be correct. This way students must carefully review all the answers and cannot stop after the first one which seems to be correct. It is worth mentioning that the order of presented answers is also random, so it is impossible to memorize only the question number and the correct answer position, and the student has to learn the entire problem and its solution. Together with the presentation of section lecture material, there opens a time window of 2 weeks when it is necessary to solve the test. After that time the test closes and it is not possible to gather points for that one, if not solved in the predicted time.

The course was presented to the two groups of students at the second semester of bachelor studies of applied informatics. There were 37 students in total taking part in the course. The course is presented in numbers in Table 1. The whole course was divided into 8 sections which were presented every two weeks to the students. Every section contained several movies of variable time length. The selection test in each section was composed of 5 questions with 4 answers. The questions were randomly selected from a larger set of questions. Table 1 presents also the mean result of grades received by students in every course section.

Preparation of an e-learning course takes significantly more time than running the same course live in the classroom. Definitely, the most time consuming work is recording of video screencasts. First of all, one has to prepare for a particular lecture presentation, which takes more or less the same amount of time as for the live presentation. Then the recording takes more time than a live presentation due to technical issues, repetitions of some recordings, edition of the already recorded material and other reasons. Teachers know that, opposite to live presentations, the recorded videos will be watched many times by many users, so they try to do their best, which is why repetitions of recordings happen and that takes more time. In case of the presented course, the recording of 1 hour of video material took on average 3:12 hours. After the video is recorded, it is necessary to master it to the final form, for which in the case of this course MP4 format was used. It consumes additional time. Also, creation of test questions is additional work that has to be done. Finally, also entering the test questions into the e-learning system is quite time consuming.

Table 1

**The course data by sections**

Section number	Number of movies	Time [h:m:s]	Number of test questions	Mean evaluation result [%]
1	7	1:11:07	24	95.9
2	5	0:52:09	20	90.9
3	7	1:00:54	14	92.0
4	7	1:29:45	20	92.5
5	8	1:22:44	20	94.4
6	6	1:07:07	14	93.6
7	8	1:13:08	22	93.2
8	7	1:06:33	21	93.4

#### 4. Discussion

The presented results show that preparation of e-learning course is far more time consuming than just running it live in the classroom. In the presented case, only recording of video screencasts takes 3 times more time than a classical course, not to mention other labor necessary for the finalization of on-line training. On the other hand, an e-learning course may be used many times later on. The effort of work is remunerative if the course is used in the future for a few subsequent years, or is taught parallelly to many students groups, which would require separate live presentations made by teacher for each group. In addition, to plain time and work calculation, there are some additional advantages of running an e-learning course. Students prefer e-learning because it gives them the freedom to manage their time and a choice of localization in which they learn. They may learn in the most appropriate time for them and not waste unnecessarily time commuting to the university classroom if it is not necessary. The possibility to repeat the recorded video as

many times as it is necessary for students to understand the presented problem is yet another advantage. In live lectures some aspects may be violated, since the lecture goes on and it is not possible to stop and discuss every single nuance of the subject. There is also a number of advantages for the teacher who prepared an e-learning course. It actually frees his time when live classes should took place. He may use that particular time for other assignments. Moreover, that freedom repeats in the future every time when e-learning is used. Material prepared one time can be used many times in the future. What is more, since students learn in their favorite time and may repeat material as many times as they wish, they learn better, which gives satisfaction to the teacher. The possibility to monitor progress of students by following their grades in every section tests is a practical advantage for the teacher. Finally, e-learning system automates final grades calculation, releasing the teacher from some work. To conclude the discussion on the presented e-learning course, it ought to be said that this solution is well accepted by students due to individual approach to their learning process. The results of teaching are no lower than with classical classroom learning. Considering all the advantages and results, it is recommended to widen the e-learning offer for students. In the current economy and technology conditions it could be a winning factor for some high schools on the market.

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