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E-LEARNING USING MODERN TECHNOLOGIES SUPPORTING INNOVATIONS BASED ON A SCIENTIFIC APPROACH

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Abstract: *This paper focuses on the evaluation of virtual distance learning during the Covid-19 pandemic in IT (information technology) courses for Operating systems and CRM (Customer Relationship Management) systems. The evaluation is based on a decision matrix and Saaty's method for working with selected metrics (criteria), such as advice from a teacher, communication, meetings, testing, time, and understanding. Saaty's method is used to calculate weights for selected criteria to determine the significance for learning. The results show the division of criteria into two groups with higher and lower impact on learning. There is a big difference between them, and this imbalance is also visible in the test results, which are on average. Communication, meetings and advice from a teacher show lower influence on learning, but they are critical criteria. The reason for this fact is that if it is difficult to live, then it is also difficult to learn about new skills. Weakness is a practical activity in seminars; there were limits to work with IT at home but cloud and virtualization helped. The interest in education is positive. Many entrepreneurs (students) have stopped doing business and this time benefited from learning and thinking about the future.*

Keywords: E-learning; information technology; innovation; key competences.

INTRODUCTION

From a public point of view, e-learning is the use of information technology (IT) in education. The first ideas about e-learning date back to 1999 and are based on computer training (What is e-learning, 2020). Since then, e-learning has taken many years to develop a comprehensive solution for education, deep learning (McTighe & Silver, 2020), or effective tasks in blended learning (Sagan et al., 2019, p. 171). This form of education is aimed at universities, schools of various levels, and also enter-

prises. The reason is the offer of a standard method for learning about current trends, training on occupational safety, or training new employees.
The importance of e-learning is always visible. It is about acquiring new skills that are needed for better work. Throughout history, books, educational and scientific literature have been the main sources of information and knowledge. The global information society has the Internet and websites for distributing large amounts of information. Information is everywhere, but its value is knowledge and critical thinking about innovation with different relationships, such as social, emotional, and cultural (Markowitz & Bouffard, 2020). At the time of Covid-19, life is closely connected with digitalization and the virtual world. And again, e-learning is irreplaceable in building progress in an innovation-based society. On the positive side, e-learning also has experience with innovation (Jarrett, 2018) and the results affect education at all times (by default and times of crises). This approach is specified from the past, present, and is also a good idea for the future combination using art and science (Marzano, 2017).

1. THE ROLE OF INNOVATION IN SOCIETY

Strong pressure creates initial competition, which is everywhere at default times, and innovation is useful help. Innovations often focus on information technology (Brown (Author) & Heitsch (Narrator), 2020) to create a new combination of existing technologies and methods into a new concept or design. This approach requires new skills and time to validate and implement new ideas into practice. Many enterprises have their own research departments and conduct regular knowledge-sharing training to promote the quality of offered goods and services, customer loyalty, revenue, and brand reputation. 2020 is different because global society lives at a time of pandemic. It is hard to live, do business, and it is also hard to think about innovation. Certainly, it is difficult to think about innovations at a time when people have doubts about life and there are many limitations. From another perspective, it is an opportunity to think about new areas of business to be successful (Gladwell & Hill, 2020). In many cases, the business was stopped. It is hard to know about future business renewals. Thus, it is time to think about innovations using information technology (for example, to support e-shopping and contact customers through online tools), or to start a business in a new area that will help other people's needs. Perhaps everyone feels that it is now more about sustainable development than at other times.
And life at a time of pandemic fosters many innovations that are implemented into our lives. Of the many, there are several examples that show the implementation of information technology in order to continue doing business:

- Automatic online sensors for inventory monitoring (Scotti, 2020).
  There are sensors that measure temperature, humidity, and other necessary data, which are automatically sent to the application. Farmers check necessary conditions for stored grain or the silage.
- The zaparkuju.cz application for discovering new parking spaces (Novak, 2020).
  This is a quick orientation in urban areas with the simplification of online payment and the possibility of booking a parking space. In the Czech Republic,

there are also parking spaces for people with disabilities and a list of charging stations for electric cars.

- Chatbot Karel Klostermann as a digital guide (Scotti, 2020).
  It is a digital guide that writes to visitors on the Messenger platform. The application offers communication with the visitor and shows interesting places in Sumava.
- A tool for automating the sales of photographs (Scotti, 2019).
  This application generates keywords and automatically assigns categories to photos using artificial intelligence. It automatically sends photos to photo banks to save time and make money.

These applications are interested in the Internet of Things (IoT), automation, artificial intelligence, and social networking because they are well known to people in a global society. To develop this application, authors combine skills from the selected area and information technology. It is also about optimal communication with customers and building a better world. And again, e-learning and education help to better implement information technology in practice. By default, it is a multidimensional task and it is important to continue this process even at difficult times such as a pandemic.

2. LIMITATION FOR E-LEARNING AT A TIME OF PANDEMIC

The advantages of e-learning are visible in many aspects such as efficiency, speed, individual approach, and lower expenses (on travel, or reduction of profit due to loss of time spent on education). Where there are advantages there are also disadvantages. The latter are: little time to study, little or no feedback, weak motivation, and also better opportunities to cheat in education (E-learning advantages, 2020). Information technology is an important part of the education process. This situation is well illustrated by data on investment in educational technologies. It is estimated that the future development of e-learning investments will have reached about USD350 billion by 2025. The focus is oriented on e-learning software, language apps, video conferencing tools, and virtual tutoring (Li & Lalani, 2020).

Various platforms are used to arrange study lectures and documents. From a global perspective, tools such as ELMS (Easyclass Learning Management System), MOOC (Massive Open Online Courses), the Moodle platform or Zoom Classroom are well known. Default requests are for educators to create online courses so that they store course materials, create tests to manage exams with assessment, and track deadlines, as well as provide feedback to students. Other communication options between faculty members and students are e-mails, messages, chat via Skype, and WhatsApp. Video recordings and PowerPoint presentations were also useful, as the educator creates instructional videos and PowerPoint presentations are accompanied by audio commentary.

At the time of the pandemic (since March, 2020), initial full-time teaching was immediately stopped. E-learning is used for all forms of education, study materials have been created, and videos with tests. The Silesian University in Opava uses the MS Teams application for online communication. The lectures were at a good level because presentations at virtual conferences or webinars are a standard part of teaching

work. It was new to some students who needed login or setup advice to attend lectures. Many of them sent additional questions by e-mail, Skype or chat in Teams application. Practical examples of seminars were a bit difficult. In full-time teaching, students see a way in which to solve these examples. It is time to think about solutions, and if possible then teacher goes to the student to repeat what is needed. The MS Teams application may project real application management and students see a solution. The teacher may also create a presentation with pictures and comments or video sequences, but still, it is one-way communication. From the teacher's point of view, the weak point was the absence of the possibility to see students' work with the application. The reason was that not all students had the opportunity to run the selected application on their own computer. In such a situation, it was an alternative choice to use an application in the cloud or life image with virtualization. Over time, it is good to evaluate lectures without full-time teaching according to metrics in order to better describe their changing impact on education.

3. EVALUATION OF VIRTUAL DISTANCE LEARNING WITHOUT FULL-TIME TEACHING IN CLASSROOM

Evaluation of education is a standard part of e-learning. Pragmatic results are visible in exams to prioritize the best ones, such as A or B or C. Another view is visible so that students have a better orientation in the topic. It is a good understanding of the necessary terms and knowing of optimal methods of work. Courses focused on operating systems and CRM (Customer Relationship Management) are about working with CRM systems and basic software, such as the operating system. Each student is an individual and what is interested in one it not interested in others. In these cases, training leads to inspiration in different IT implementations so that they may be combined for innovations. In this regard, metrics must reflect different preferences and goals. There are many approaches to evaluation, such as:

- Training metrics for measuring the effectiveness of e-learning (Ibraeva 2019).

Training is associated with increasing performance and success in business. Metrics focus on reactions, learning, behaviour, and outcomes. The reactions are about satisfaction with teaching, learning is about new skills and the level of knowledge, the behaviour is the ability to apply new skills in practice, the outcomes are visible in changes in society.

- Key learning metrics (Sharma 2018).

This approach prioritizes metrics such as completion rate, student progress, student satisfaction, manager (educator) evaluation, and student competence. The completion rate shows the level of student participation, the student's progress provides information on the success rate in online training and assigned tasks, and student satisfaction from online training. The evaluation of the manager shows active participation and motivation. For the last metric, student competence is the ability to declare that the student has the necessary skills and knowledge.

- E-learning success metrics (Yengin et al. 2011, p. 1396).

This method is more of a history, but it shows a comprehensive view of success metrics. There are metrics such as system quality, quality of information, service qual-

ity, user satisfaction, and network benefits. System quality monitors the level of user-friendly, safe, and fast. The quality of information focuses on competencies, well organized, and useful. Service quality is about availability, responsibility, and knowledge. User satisfaction is interested in the overall success and the network benefits are about saving time, but also in isolation and lack of contact.

The inspiration for this paper is based on a decision matrix (Boogaard, 2018), with which to evaluate learning at initial times (full-time teaching) and at pandemic times (virtual distance learning without full-time teaching in the classroom). It is a tool for analyzing individual options according to specified metrics (criteria). The necessary metrics were selected such as advice from a teacher, communication, meetings, testing, time, and understanding. Advice from a teacher focuses on the ability to help every student who needs it. Meetings are focused on the necessary interpretation about a given topic based on a syllabus of accredited courses on realized events. Testing always plays an important role; therefore this metric is also selected. The latest metrics focus on time and understanding. From the teacher's point of view, it is more about trust between students and educators. This aspect is important in communication between people, and it is more important at the time of pandemic.

The method of learning evaluation for lectures and seminar activities is derived from the method of creating a decision matrix. First, it is necessary to create a table in which the individual rows are focused on lectures and activities in seminars, in order to evaluate the various work during full-time and distance learning. The columns focus on criteria (selected metrics) for learning assessment (see Table 1).

Table 1

Evaluation of learning in focused courses on operating systems and CRM systems

Evaluation of learning according to the form of education	Selected metrics (criteria)					
	Advice from a teacher	Communication	Meetings	Testing	Time	Understanding
Default full-time teaching						
Lectures	4	4	3	3	3	3
Activities in seminars	5	5	5	5	3	4
Distance learning during a pandemic						
Lectures	3	5	5	3	4	4
Activities in seminars	2	1	4	2	2	2

Source: Own work.

Selected criteria (metrics) were evaluated on a scale from 1 to 5 (1 = weakest, 3 = average, 5 = best). By default, full-time teaching is a recurring classroom meeting based on an assigned schedule and an accredited course focused on operating systems and CRM systems. It is the starting activity and the rating is linked to the average number 3 in multiple criteria. Practical activities in seminars are preferred and assigned the highest number for advice from a teacher, communication, or meetings. This is also better for understanding because practical work supports a good orientation in the topic and students are in a better position to innovate in business. This criterion is evaluated 4.

During a pandemic, virtual distance learning changes the initial meetings and face-to-face speaking is limited. The learning was realized with the support of the e-learning website, the university information system, local disks, which are accessible via a web browser, familiar e-mail, and the Teams application for communication in virtual form based on microphone, headphones, and camera. On the positive side, meetings were not limited in time and teachers may respect students' preferences. This is not a schedule-based time. The higher rating is also for lectures, as educational documents have always been available as the default, and communication with students has taken place with the support of presentations through the Teams application (voice, pictures, videos, and chats). The weakness is evident in the activities in seminars. The reason is the limitation of the working environment to operating systems and CRM systems. It was impossible to teach in classrooms on computers and it was necessary to use cloud or mobile solutions. Another aspect was that it was easy to show the right capabilities of selected applications and operating systems for students, but in some cases, it was one-way communication. Students had no ability to repeat the necessary activities on their own devices or cloud applications. It was about patience and respect that this time was unexpected for everyone. These reasons have the effect that the evaluation of activities in seminars is lower. A higher rating is assigned to meeting because students were interested in continuing their education and inquired more and more through chat and e-mails.

It is good to see more a complex evaluation of learning based on multicriteria managerial decision making according to Saaty's method. Saaty's method was developed by Professor Thomas L. Saaty (Creative Decisions Foundation, 2020). Saaty's method is well known and permits one to take measurements in changing conditions. For the evaluation of learning, it is important to determine the weight of each criterion. This method is divided into a three steps:

- Creating a table to determine the Saaty's matrix S.

The created table (Saaty's matrix $S = s_{ij}$, where i, j = 1, …, n) is defined by the calculation specification for the evaluation of six selected criteria (n = 6), such as advice from a teacher, communication, meetings, testing, time, and understanding. The numbers of the matrix represent estimates of the proportion of the weights between two criteria i and j. The degree of importance is evaluated by numbers from 1 to 9: 1 – equivalent criteria i and j, 3 – slightly preferred criterion i before j, 5 – strongly preferred criterion i before j, 7 – very strongly preferred criterion i before j, 9 – absolutely preferred criterion i before j. Values 2, 4, 6, 8 – express intermediate levels (see Table 2).

- Specification of weights using a geometric diameter to be applied on the matrix S (Saaty, 2008).

The resulting weights v_i for i = 1, …, n are calculated according to the formula:

$$v_i = \frac{\left(\prod_{j=1}^{n} s_{ij}\right)^{1/n}}{\sum_{i=1}^{n} (s_{ij})^{1/n}} \quad (1)$$

(see Table 3).

- Validity verification of the matrix S to avoid inconsistencies.

Weight specifications may not always be correct. It is necessary to do a validity verification. To verify the validity of the table, it is necessary to calculate the consistency ratio (CR) using the consistency index (CI), the random index (RI) and the largest eigenvalue of the matrix (λ_{max}):

$$CR = \frac{CI}{RI} \quad (2),$$

where $CI = \frac{\lambda \max - 1}{n-1}$, and RI = 1.24 for n = 6.

If CR is less than 0.10, it indicates that Saaty's matrix is reasonably consistent.

Table 2

Saaty's matrix for the evaluation of learning in targeted courses on operating systems and CRM systems

Evaluation criteria (metrics)	Advice from a teacher	Communication	Meetings	Testing	Time	Understanding
Advice from a teacher	1	1/5	1/2	1/3	1/7	1/7
Communication	5	1	1/2	1/3	1/5	1/7
Meetings	2	2	1	1/3	1/3	1/5
Testing	3	3	3	1	1/2	1/7
Time	7	5	3	2	1	1/2
Understanding	7	7	5	7	2	1

Source: Own work.

Table 3

Calculated weights for selected criteria (metrics) for the evaluation of learning in targeted courses on operating systems and CRM systems

Evaluation criteria (metrics)	Weights (v_i for i = 1, …, 6)
Understanding	$v_1 = 0.448$
Time	$v_2 = 0.250$
Testing	$v_3 = 0.129$
Meetings	$v_4 = 0.077$
Communication	$v_5 = 0.062$
Advice from a teacher	$v_6 = 0.034$

Source: Own work.

Last step is to validate the table to avoid inconsistencies. This is the consistency ratio CR, where CR = 0.102/1.24 = 0.082 (λ_{max} = 6.511). Because CR is less than 0.10, Saaty's matrix is reasonably consistent.

Based on the calculated weights, the selected criteria are divided into two groups. The first group (such as understanding, time, and testing) has a higher impact on learning. It is acceptable to have such results because the great benefit of learning is to understand the activities performed at a given time, and it is good to declare new skills by

testing. The second group (such as meetings, communication, and advice from a teacher) has a lower impact on learning. From a pragmatic point of view, educational materials are available online, and there is no need to meet face-to-face or online in a virtual space. In addition, many resources are available on the Internet; therefore, students have opportunities to know about new approaches. However, there are difficulties in understanding and there is a lack of good orientation in the topic and suitable resources from the Internet. This disproportion seems to have a deeper meaning, and this is visible in the actual test results at the time of the pandemic without excellent results. From a pragmatic point of view, the teaching of test results (from A to F) was also different. At the initial full-time teaching, there is variability and students have exams from the entire spectrum. Now the exam period is in the middle (will end on August 31, 2020), but exams are completed in C and D. Education is always about mutual communication between teachers and students. It is the basis of work for understanding the implementation of information technology in practice and continuing innovations according to their own preferences and skills. It is the same during a pandemic. The following words of a student from a survey on learning experiences mirror this situation: "the subject is practically focused, the teacher communicated and lectured during the coronavirus … great".

CONCLUSION

Education is always important for all areas of human activity. In many cases, it is associated with the possibilities of information technology. This year is different. Covid-19 changes plans and many activities have been cancelled. The evaluation of learning during a pandemic has strengths and weaknesses. The great interest in e-learning and the fact that students are interested in participation at lectures in a virtual form are positive. Weakness was practical work in seminar activities. In some cases, it was one-way communication because it was difficult for some students to repeat the work with operating systems and CRM systems. Saaty's method was used for a more detailed evaluation of learning. Saaty's matrix S and weights were calculated for selected criteria to show the effect on learning. Understanding, time and testing have a higher impact on learning (more than 10%). And meetings, communication and advice from a teacher have a lower impact on learning (below 10%). This difference is not good and affects the test results, which in many cases reach an average level. This is also reflected in the large gap between intensive communication with a teacher (via the Teams application and e-mail) and exams with results between C and D. There are also a number of students who must complete the exam yet.

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