

Implementation of Virtual Laboratory of Electronic Commerce Into University Course

Martin Vejačka¹

¹ *Department of Applied Mathematics and Business Informatics, Faculty of Economics, Technical University of Košice, Slovakia*

Abstract – Plenty of information and communication technologies are frequently employed in educational activities to improve the opportunities for students to gain knowledge and experience, including the virtual laboratory. The virtual laboratory is quite often implemented into educational process in many science, technology, and engineering courses at the university level of education. However, the use of virtual laboratory in the field of electronic commerce education is rather rare. In our educational practice, a virtual laboratory of electronic commerce was designed and implemented within the course of electronic entrepreneurship. This paper presents the design of the virtual laboratory of electronic commerce and provides an outline of its integration into the university course's teaching process. The study examines the learning progress claimed by the students who participated in the most current edition of the course delivered utilizing this virtual laboratory. The findings revealed improvement of course participants' experience and abilities in the field of electronic entrepreneurship in e-commerce.

Keywords – Entrepreneurship education, higher education, e-Commerce, virtual laboratory.

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Corresponding author: Martin Vejačka,
Department of Applied Mathematics and Business Informatics, Faculty of Economics, Technical University of Košice, Slovakia


Email: martin.vejačka@tuke.sk

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1. Introduction

Electronic commerce (or e-commerce) is now a very important aspect of modern business. The term e-commerce denotes the enabling of the interchange of products or services using information and communication technologies (ICTs) such as electronic data interchange, electronic payments, digital marketing tools, business intelligence software, and others. It allows delivering the company's products to a broader variety of possible clients. E-commerce may also include the usage of economic information systems, such as e-shops, online marketplaces, online sales promotion, and electronic public administration services [1].

Electronic commerce is naturally linked with e-payments or with electronic banking in general. It allows virtually uninterrupted access to payment services for both businesses and their customers. Its access to electronic payments is not restricted to the business hours of traditional brick-and-mortar branches of the company. Furthermore, e-payments enable to carry out transactions almost from every place around the world around the clock, thus saving time and costs for the e-commerce company.

E-businesses like other types of businesses are obliged to communicate with public administration authorities to accomplish their legal commitments. In the field of communication with public administration authorities, again the ICTs are facilitators representing the eGovernment services for businesses (government-to-business form of eGovernment) [2].

An increasing number of companies shift to conducting their business online or in an electronic environment. Therefore, there is a growing need for university graduates knowledgeable in the field of e-commerce. When teaching potential future entrepreneurs in the area of e-commerce, it is proper to incorporate all of these aspects so that students can gain as much experience with the management of such firms as feasible.

Aside from the consequences on businesses described above, information and communication technologies are commonly used to support the educational process and help students expand their knowledge and abilities [3]. Therefore, the use of e-learning for providing education in the field of e-commerce is a logical option.

E-commerce companies sometimes use the elements of virtual experience used to provide a pre-purchase experience with products. This virtual experience (mediated by a virtual lab) is vivid, involving active affective psychological states occurring in a potential customer interacting with 3D computer simulations [4]. Virtual experience usage in product marketing leads to more accessible and confident brand attitudes [5]. However, it is possible to provide virtual experience also for potential future entrepreneurs in the field of e-commerce during their educational process. ICTs can support such an educational process to varying degrees, but given the digital nature of e-commerce, it is ideal to involve them as much as possible. Probably the best way to get an education in the field of e-commerce is to try real-life entrepreneurship in this field. If it is necessary to keep the condition of free-of-charge education for students, it is advisable to simulate such an environment with the use of ICTs. In our practice, a so-called virtual laboratory of e-commerce was created to simulate the operation of such an e-commerce company, including the process of its establishment, in order to provide students with the necessary knowledge and experience. In this article, we will discuss the concept of a virtual laboratory of electronic commerce, its benefits, how it can be implemented into educational process, and how this was reflected in our practice.

2. Literature Review

Virtual laboratory (or virtual lab) in general is a computer-based simulation or software environment that replicates the experience of a physical laboratory. It provides students with opportunities to conduct experiments and observe natural phenomena or to learn and apply concepts and techniques in a simulated environment. Virtual laboratory enables users to perform and replicate experiments and investigate scientific phenomena in a virtual world [6]. Virtual laboratories are intended to replicate the equipment, procedures, and interactions that would normally occur in the real world, and they frequently include interactive elements, such as digital instruments, instruments for gathering data, and visual representations of experiments, to provide a stimulating educational environment [6].

Virtual laboratories have emerged as a valuable tool for teaching a wide range of topics, mainly in the fields of natural sciences. Virtual laboratories have gained popularity due to their numerous advantages. They provide users with accessibility since they are capable of being accessible online via computers or other internet-connected devices. They also provide safe conditions for experimenting, eliminating the hazards involved with dealing with hazardous substances or costly equipment. Furthermore, virtual laboratories are more affordable since they do not require physical infrastructure, maintenance, or disposable resources. However, virtual laboratories should not substitute physical ones and their advantages are better realized when combined with traditional hands-on sessions [7].

Virtual labs have been used to teach disciplines such as physics, chemistry, biology, and earth science in the natural sciences. Computer-generated experiments within the virtual laboratory can provide a safe and cost-effective alternative to physical laboratories while still allowing students to engage with and handle equipment as well as witness natural phenomena in a realistic and engaging interactive manner [8]. For the usage of virtual laboratories in natural sciences speak their multiple advantages. Some studies indicated a high increase in students' enthusiasm, they had the feeling that they were inside the chemical reactions and they were facing the 3D molecules as if they were real objects in front of them when using a virtual lab [9]. Virtual labs can be also available to course participants at any time and from any location as long as they have the Internet connection and a computer or mobile device [10]. As a result, they can be used for distance learning or by students who do not have access to a real laboratory. This feature of virtual laboratories also helped to overcome COVID-19 pandemic prevention measures, as it was possible to continue the educational process also during lockdown times [10], [11].

Furthermore, it is safe to use virtual laboratories for students without the risk of damage to equipment or even injury, which is especially important when working with hazardous or costly materials. Moreover, they do not need the purchase of expensive equipment, materials, or laboratory spaces which indicates the cost-effectiveness of virtual labs.

Virtual laboratories can truly simulate the experience of a physical laboratory, enabling students to operate equipment and see natural occurrences in a realistic and engaging manner. Additionally, virtual labs may be tailored to the needs of individual students and learning objectives.

This enables teachers to create experiments that are suited to their students' unique requirements, as well as to provide feedback and help to individual students. Virtual laboratory applications have positive effects on students' achievements and attitudes when compared to traditional teaching methods [12].

Students may study natural phenomena and perform experiments in a way that is frequently not feasible in a real laboratory thanks to the use of virtual laboratories. This can be an incredibly fascinating and participatory learning tool and it may encourage students to pursue the natural sciences and boost their interest in these subjects. Virtual laboratories in natural sciences, therefore, offer plenty of advantages and possibilities for students to study and explore the physical world in a safe, cost-effective, and entertaining environment. They may be a great adjunct to traditional laboratory experiences and can be used for both in-person and distance learning [12]. Virtual laboratories are (for over two decades already) useful tools for education within technology and engineering education [6]. Virtual labs can be tailored to meet the specific learning objectives and needs of different student groups. Educators may create experiments, change the parameters, and add different situations to fit the curriculum and target certain educational goals [13]. Furthermore, the laboratory environment can be equipped with functionality for monitoring the student's progress and learning outcomes, thus enabling skill-based assessment.

Virtual labs may often include tools for data analysis and visualization. As they conduct their experiments, students may gather data, create graphs, run statistical analyses, and make conclusions. Their data literacy and analytical abilities are improved by this capacity. Furthermore, virtual labs might have incorporated simulations and modeling tools, thus allowing students to investigate complicated mechanisms and phenomena that are hard to reproduce in conventional lab settings [14]. Virtual laboratories are used within the educational process in various fields, for example:

- chemistry [9], [12], [15],
- physics [16],
- astronomy [17],
- biology [18],
- information technologies and their security [19], [20],
- mechanical engineering [13], [21],
- electronic engineering [22],
- and even other fields of education [6], [23].

Nevertheless, it most often involves the usage of virtual reality (VR) to emulate the environment of a real-life laboratory for such an educational process with multiple sensory features.

Though, in the field of electronic commerce are virtual laboratories rather used without the implementation of virtual reality (i.e. without the use of a graphical virtual environment and VR sets, etc.). Virtual laboratories might be also used for the purposes of entrepreneurial education [24]. Virtual laboratories are used in electronic commerce education to educate multiple concepts including online markets, payment methods, security and privacy, and customer experience. These simulations can provide students with a flexible and interesting opportunity for improving their e-commerce abilities and test out various tactics without the dangers and costs connected to a real laboratory. In general, a virtual laboratory of electronic commerce is an online platform that simulates actual e-commerce scenarios. It enables students to practice completing e-commerce transactions without taking on the dangers involved in real purchases. Typically, the virtual laboratory is made up of several modules that address different facets of e-commerce, including website design, online marketing, payment methods, and customer support [25]. Users may engage with the topics and practice what they are learning while getting feedback and direction as they navigate through the virtual lab.

Using a virtual electronic commerce lab has many benefits. A virtual laboratory primarily offers a secure and regulated environment for individuals to obtain actual experience with e-commerce [26]. This is crucial for those just entering the profession who might be reluctant to do actual transactions. They can gain confidence and hone their talents by utilizing a virtual laboratory without running the danger of the negative effects of blunders or faults. There is a possibility to concurrently educate an extensive number of participants using a virtual laboratory [27].

It may be accessible from any location with the Internet connection, in contrast to conventional training techniques that demand physical resources and the presence of a trainer. As a result, it is a more economical and effective training strategy. Virtual laboratories for e-commerce may eventually be easily updated and changed [28]. New technology and best practices appear as e-commerce develops. Individuals may keep current with developments in the sector by utilizing a virtual laboratory, ensuring that their skills and expertise are still useful and valued. A virtual laboratory for electronic commerce must be implemented in a number of crucial ways. The platform must first be established and designed. Typically, this entails the construction of user feedback systems, the integration of interactive components, and the design of the modules. Furthermore, the virtual lab has to be examined and improved.

The user testing is required in order to make the virtual reality application efficient, simple to use, and serve the demands of its intended audience [29].

Available literature lacks the information on possible design of a virtual laboratory of electronic commerce using integration of multiple information systems (e.g. e-shop, e-payment system, electronic registry, etc.) for supporting the entrepreneurship education. Therefore, our paper will present possible concept of such virtual laboratory of electronic commerce and its use in educational practice.

3. Virtual Laboratory Design

There are many different ways, levels, and formats in which information and communication technology can be implemented within the educational process. The ability to grasp and use ICT is currently one of the key elements of an entrepreneur's success in e-commerce. It resides in their capacity to get oriented in a wide range of knowledge relevant to their industry. That advocates the use of ICT in the training of aspiring businessmen in electronic commerce. One option for a thorough ICT integration into education is a virtual lab. The concept of the virtual laboratory can be also defined as an environment of multiple ICT systems that enables the simulation of some kind of activity [24].

In our case, the education model of the virtual laboratory of electronic commerce was chosen to educate potential future e-commerce entrepreneurs. Over the last decade, there was developed virtual laboratory for emulating the business activities of a newly established electronic commerce company for teaching purposes in the university course called Economic Information Systems (EIS). The EIS course is provided to the students in the second year of master's degree study in the field of Business Informatics and has optional character, so students can voluntarily choose to attend the course from variety of courses. The problem-oriented learning and learning-by-doing methods are employed within the frame of the EIS course. This course intends to educate students on how to run a small virtual firm utilizing information and communication technology from the moment of firm's founding until the first annual closing of accounts. Participants should advance their understanding of the ways of electronic communication with the public administration authorities (business to government and government to business eGovernment communication) legal, tax, and electronic accounting systems, and especially fundamental electronic commerce skills, website design, and online shop administration and management.

The virtual laboratory of electronic commerce incorporates a virtual payment system, an electronic registry with the support of digital signature certificates, and electronic shops of virtual firms of students. The educational process within this virtual laboratory in the EIS course is also supported by the platform of the learning management system (LMS) Moodle. It also serves for rudimentary communication among course participants. LMS Moodle houses all of the learning materials for the course and all course activities and schedules are displayed there, so participants may see if they accomplish deadlines. Participants also upload all fulfilled tasks into Moodle. Evaluations of these tasks are also provided there by the lecturers. The EIS course, therefore, has a character of distant learning. The benefit of distance learning is that students are not forced to attend lessons or lectures at a specific time. Through emails, live chat, and the learning management system, they may contact their instructor whenever they want. Their job may be done autonomously from home, at the office, or virtually any location with the Internet connection. However, the LMS Moodle cannot be counted as a part of our virtual laboratory of electronic commerce, its role in the educational process of the course is vital.

The curricula of the EIS course are oriented on the conditions and valid local legislation for e-commerce. Learners in the course buy and sell items in the virtual retail market in the role of a small virtual business. Each course participants establish one small company acting as its owner and also manager. Students set up their businesses in accordance with local legal requirements (i.e. Slovak legislation). To simulate public authorities (company register, financial administration office, license register, social insurance office, healthcare insurance authority), a virtual registry run by instructors is employed. Business plans are created and all essential documentation (foundation deed, registrations, licenses, etc.) is finished prior to the company's official launch.

If all legal requirements for the e-commerce businesses' establishment have been satisfied, participants should create their websites as a presentation of their company. Additionally, students incorporate the supplied e-shop solutions into their websites to be able to offer their virtual goods on the market. They purchase things for further trade from a central wholesale e-shop run by teachers, which is the source of their merchandise. By making purchases from other students' e-shops, other students act as their virtual customers, as they take the role of private individuals in this situation to create some demand for products.

By making purchases from students' online stores, lecturers also contribute to demand in another way. The virtual payment system is used to transmit every payment made in online stores and offers also startup financing (in a form of a loan that has to be repaid from the revenues of the virtual firm) to all student-owned enterprises.

All participants' companies are required to maintain electronic records of their accounting for the current business period. Participants produce their financial statements and then perform a strategic analysis after the simulated conclusion of the first business period. Strategies for the business's future development are included in this report. Students also evaluate parts of the virtual laboratory utilized in the course and provide course-related comments at the course's conclusion.

The component parts of the virtual laboratory of electronic commerce are following:

- virtual registry – serving for firms' registration with virtual public administration authorities (business register, license register, financial administration office, social and health insurance institutions),
- virtual electronic shop – web domains at the server for web presentations of participants' virtual firms including installation of e-shop open source solution,
- virtual payment system, allowing payments for virtual products traded within the environment of the virtual laboratory.

Within the EIS course, the virtual registry acts as a fictitious representation of public administration agencies. Participants need to employ electronic communication to communicate with these virtual public administration authorities while establishing their virtual companies. This communication must be in accordance with current valid legislation. Participants have to register their companies with the Business Register and Trade Licensing Register. In addition, they must register their newly formed businesses with the Social Security Administration, the Healthcare Insurance Company, and the virtual Financial Administration office. There are electronic versions of every required form. Following completion of those forms, PDF files are prepared and submitted via the virtual registry. Applicants must use a digital signature to sign their application forms. The topic of digital signature and its usage within electronic communication with virtual authorities is an important part of the course's curricula. Digital signature certificates are provided to participants by Sectigo certification authority and are also valid for internal communication at our university.

The PDF files created by students need to be digitally signed using Adobe Acrobat Reader. General information on employing digital signatures for authentication and communication is provided for participants. It describes how a digital signature may be used across all aspects of e-government. Participants in the course are first acquainted with the concept of Public Key Infrastructure (PKI) [30]. While creating their digital signature certificates at the certification authority, they also get some hands-on PKI experience. Participants in the EIS course can practice using a digital signature by digitally signing all required documents in electronic form (and delivering them to the appropriate virtual authorities). The EIS course's curriculum accurately depicts local basic alternatives for communicating with public administration officials.

Websites with included electronic shops simulation is an important feature when teaching electronic commerce [31]. In our case, our students prepare websites and implement open-source e-shop solution within its framework. The electronic shop (e-shop) of virtual businesses of our course participants (as a part of the virtual laboratory of e-commerce) is based on open software solution named OpenCart. The virtual e-shop is a linked subpage of the virtual company's website, which is created and maintained by student – establisher, and owner of the company. Establishing and maintaining an online shop that is connected to their website is the primary electronic commerce activity of students in the course. The central wholesale e-shop, run by instructors, is where all of the commodities in participants' virtual businesses are sourced. The goods are of a virtual nature and are added to the central e-shop's inventory without incurring any production costs.

Users may purchase items from the three product categories (computer equipment, office equipment, or office furniture) from the central wholesale e-shop (for further commerce in individual e-shops). By making purchases from students' stores, lecturers help to create some demand. In order to replicate demand in participants' e-shops, participants should purchase items from the e-shops of other participants (selling products from two different categories of commodities). Students in the course also use websites to advertise their companies. It serves as the primary instrument for the company's marketing campaigns and should encourage potential consumers to shop at the company's e-shop. To purchase a product from a certain company, users must first register in the e-shop. Participants in this section of the course get the chance to use the virtual laboratory to experience both sides of the purchasing process in an e-store.

The virtual bank enabling electronic payments is a component of the virtual laboratory of e-commerce. The need to manage electronic payments for the items purchased arises from online transactions. These payments are made using the faculty's virtual bank's online payment system. The virtual bank represents the installation of an outdated banking program offered to our educational institution freely by its producing company.

For the purposes of the EIS course's educational goals, the electronic payment functions of EOB are sufficient. As a loan to assist with the course's payment procedures, participants receive virtual money to their newly created bank accounts. Any electronic payment performed at an online store will take the customer to the virtual bank's Internet banking form, which is already filled up with the details of that specific payment for the purchase. The authorization component within the virtual bank uses a digital signature. Digital signatures are also used to complete the bank user identification procedure when logging into the payment system of the virtual bank.

All students learn practical as well as theoretical concepts regarding the safety of the payment system while making a digital payment. Most frequently, a user's safety conduct determines the security of using electronic payments. Participants in the course will understand the precautions to take while making online payments and seek to implement them in their real-life practice [32]. The integration of the e-shop with the virtual bank's payment system to enable the automated transfer of payment information posed the largest technological obstacle in the construction of the virtual laboratory of electronic commerce.

4. Methodology

The main purpose of the research was to identify the changes in students' knowledge, skills, and attitude within the field of e-commerce entrepreneurship.

Focusing on the subject of electronic commerce entrepreneurship, this study aimed to explore students' pre- and post-course experience and positions towards doing business in electronic commerce area. Our virtual laboratory of e-commerce is gradually built over the years and is adapted to various external changes (e.g. technology, legislation, etc.). In addition to these influences, it is important to monitor the students' perception of the course. Therefore, their feedback on the course is continuously collected after the course as well as information about their experience in relevant areas before the course starts. Thanks to this, it is possible to perceive a shift in their knowledge, experience, and attitudes in the relevant areas touched by the educational process in the virtual laboratory of electronic commerce.

Thus, two surveys were carried out; the first one before the start of the course and the second one at the very beginning of the course so that these positive changes could be detected.

The complete population of the course participants (78 students) in the most recent iteration of the EIS course participated in both of the surveys. The full return (100%) of questionnaires was achieved by making it a mandatory task in the course tied to the gaining of a credit evaluation. Both surveys were distributed in the form of an electronic questionnaire and students had time and space to attend the survey during the seminars (first and last) within the EIS course. Questionnaires were prepared using Google Forms and data gathered was subsequently processed using IBM SPSS Statistics 19.

5. Results

The web questionnaire was used to administer the survey online and 78 filled-out questionnaires were gathered (in both pre-course and post-course surveys).

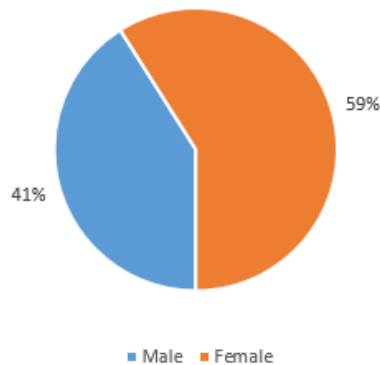


Figure 1. Gender composition of the sample

Most of the respondents 46 (comprising almost 29% of the students) were female students and the rest 32 students (41.1%) were male course

participants. This composition roughly corresponds to the overall composition of the student count in our educational institution.

Table 1. Socio-demographic characteristics of respondents

Characteristic	Frequency	%
Gender		
Male	32	41.1
Female	46	58.9
Total	78	100
Age		
18-20	23	29.5
21-23	49	62.8
24-26	6	7.7
Total	78	100
Employment Status		
Student only	43	55.1
Part-time employed	28	35.9
Full-time employed	5	6.4
Self-employed	2	2.6
Total	78	100
Monthly Income level		
Below 500EUR	57	73.1
Between 500 and 750EUR	11	14.1
Between 751 and 1000EUR	3	3.8
Between 1001 and 1250EUR	4	5.2
Above 1250EUR	3	3.8
Total	78	100

Most of our respondents (49 students i.e. 62.8 percent) were between 21 and 23 years of age, followed by the age group of 18 to 20 years old (23 being 29.5 percent of respondents). The remaining 6 respondents (7.7 percent) were between 24 and 26 years of age.

More than half of the course participants (43 respondents over 55 percent) did not indicate any employment. Almost 36 percent of students (i.e. 28 students) are part-time employees, mostly in temporary jobs. In addition to that 5 of our students are employed in full-time jobs alongside their studies and 2 other students are self-employed.

The employment status of respondents reflects in their monthly income level. Over 73 percent of them have a monthly income below 500 EUR, mostly

pocket money from parents or salary for part-time work. Income between 500 EUR and 750 EUR was indicated by 11 course participants and income between 751 EUR and 1000 EUR was stated by 3 students. All respondents from these two income levels were part-time employed. Income between 1001 EUR and 1250 EUR was adduced by 4 respondents (5.2 percent) and higher income by another 3 respondents (3.8 percent). All respondents indicating monthly income levels in these two ranges were either full-time employed or self-employed.

In order to investigate the benefits of such a form of education in the field of e-commerce, a questionnaire survey among students was conducted before the start of the course and after its conclusion. At the start of the EIS course, the following results were recorded. Because students had already taken business law courses in prior years of study, all participants had theoretical familiarity with the creation of the firm and with business legislation and regulation in general. Only 2 percent of participants said they had some practical experience creating or operating a company, while the remainder claimed no previous experience with electronic commerce business at all.

All respondents acknowledged previous experience with business plan preparation, which was due to the nature of their past courses at the university they attended. Only one respondent had experience with establishment of a company. Below 2% of respondents said they have used a digital signature in e-government applications, representing the same participant that already has some experience with establishing the company in real life.

Almost 19 percent of those surveyed indicated some previous experience with communicating online with authorities, but only as individuals, not as enterprises or corporate representatives. This finding indicates that e-government is not widely used in Slovak conditions [33].

The vast majority of responders (98 percent) had prior experience developing a basic website, largely as a result of their prior coursework at our university. None of the students had any prior experience setting up, running, or connecting an online e-shop.

More than 85 percent of respondents mentioned having made purchases in actual online stores. Although all of them stated having some real-world experience with online electronic payments, but only from the perspective of the buyer. Only less than 2 percent had the experience with the administering and managing an e-shop in praxis.

Every participant mentioned having some theoretical accounting knowledge, but only 3 percent of them had any actual accounting experience in real-world business.

Around 35 percent of respondents mentioned prior experience with developing a company strategic plan as a component of a company's long-term development strategy. In these important areas of electronic commerce entrepreneurship all of the course participants gained practical experience during the EIS course.

Following figures illustrate students' self-reported gains of practical experience in investigated areas related to electronic commerce.

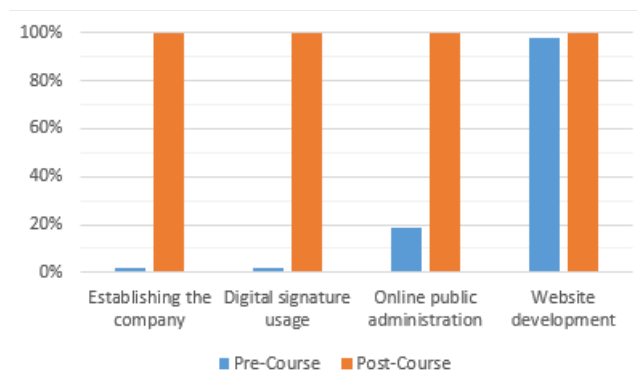


Figure 2. Measure of self-reported practical experience with areas related to e-commerce – first part

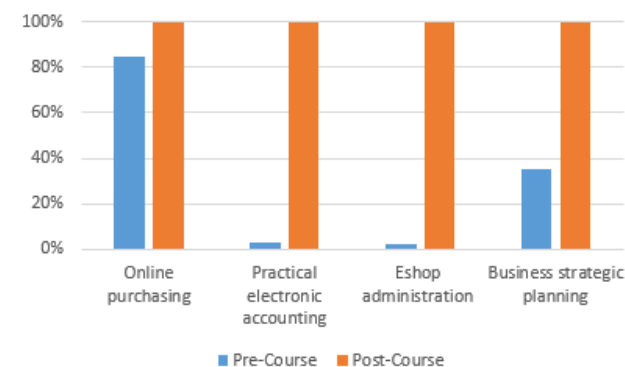


Figure 3. Measure of self-reported practical experience with areas related to e-commerce – second part

This pre-course survey shows that students on average had some basic knowledge or even experience necessary within the field of electronic commerce entrepreneurship before beginning the EIS course, which they obtained throughout the earlier years of their studies. After the students took the Economic Information Systems course and finished it, a second survey was conducted. The findings are further presented.

Nearly 97 percent of respondents agreed that taking the EIS course helped them get valuable experience in starting or running a business. More than 90 percent of the course participants claimed they did learned anything new about the procedure for setting up a business within the valid legislation.

Despite having some prior experience with business plan production, more than 61 percent of respondents claimed that the practical drafting of the business plan for their virtual organization was valuable for them.

More than 86 percent of the course participants stated it was helpful for them to have hands-on experience communicating electronically with virtual public administration authorities utilizing the virtual lab's electronic registry. Almost 73 percent of students also noted that digital signature usage in the context of this communication was a valuable experience.

Even if students had already created a website for their studies, more than 32 percent of respondents said that developing a website for their own firm gave them some new learning opportunities. For over 72 percent of students, creating and running their company's online store was a worthwhile experience. Students primarily valued the opportunity to observe how an online shop operates from the perspective of its administrator.

Nearly 59 percent of EIS course participants said it was useful to have the option to try to keep an accounting of their virtual companies like in real practice. Students specifically emphasized the experience with the initial accounting period. Around 72 percent of students also valued the assignment of creating a long-term strategy for their virtual firms (even if it was beyond the scope of the current course). Following figure illustrates self-reported improvements in students' experience in multiple aspects of doing e-commerce business.

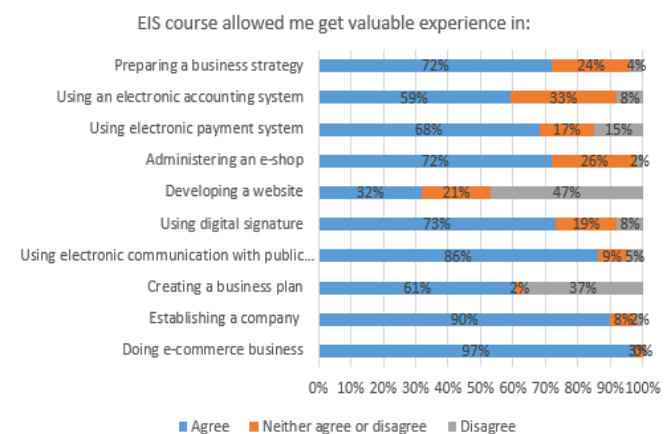


Figure 4. Measure of self-reported practical experience improvements within areas related to e-commerce

The vast majority of students (89%) rated the Electronic Information Systems course very positively and appreciated the chance to practice business with the help of a virtual laboratory for electronic commerce.

6. Discussion

The paper provided information on possible design of virtual laboratory of electronic commerce that is already implemented in the university course. Improvements in students' skills, knowledge, and experience were investigated using pre-course and post-course surveys. The data obtained suggest that our design of a virtual laboratory might be suitable for university education in the field of electronic commerce as students self-reported considerable improvements in practical knowledge of electronic commerce.

Our virtual laboratory was designed in the form of cooperating modules as suggested by Coffman and Weaver [25] and also supported providing feedback during the course to the students. Possibilities of simple modifications and changes in the design of the virtual lab are included according to the recommendations in [28] so that it is possible to react to changing external conditions in the field of e-commerce.

Unlike the virtual laboratory described in [24], which was focused on knowledge sharing and communication, our proposal is focused on gaining practical experience with e-commerce in the form of creating and running a small e-commerce company by the students themselves. Virtual registry emulates the electronic communication with the public administration authorities necessary for establishing the e-business company in local conditions. The usage of digital signature represents new skill and knowledge acquired by students in this part of the virtual laboratory and it was welcomed by its users.

The electronic shop simulation is an important feature of electronic commerce education and represents also the core of our virtual laboratory [31]. In cooperation with other parts of the laboratory, it allows simulation of the functioning of a small company focused on buying and selling goods using a webpage with an integrated e-shop. In this part usage of pre-set open-source solution significantly facilitated the establishment of participants' e-shops.

Virtual electronic payment system helps to overcome the reluctance of future potential entrepreneurs in electronic commerce to do actual transactions while doing them in a secured and regulated virtual environment as suggested in [26]. Also, the important feature is to practice secure execution of electronic payments, which is allowed by the environment of our virtual laboratory of electronic commerce [32].

Usage principles of learning by doing within the virtual laboratory of electronic commerce allowed us to practically educate a relatively high number of students in electronic commerce at the same time. This finding is in accord with the results of study

[27] stating that the usage of a virtual laboratory is an economically effective educational approach.

7. Conclusion

The virtual laboratory of electronic commerce has been designed according to the requirements for training under local conditions, as well as recommendations found in the relevant literature in this area. It focuses on electronic communication with virtual institutions including the use of digital signatures, virtual e-shop management, and secure electronic payments.

Our virtual lab allows us to successfully educate individuals in the field of e-commerce while they acquire practical experience with the operation of a small company in a safe virtual lab environment. Also, this learning process is cost-effective and allows gaining practical experience with electronic commerce.

Graduates of the training using the virtual laboratory of electronic commerce appreciate especially the possibilities of practical experience in the establishment and operation of a virtual company, the use of digital signatures in the framework of electronic communication, administration of an e-shop, and related electronic payments.

Due to rapid technological development, it is necessary to adjust the functioning of a virtual laboratory of electronic commerce through continuous modifications, which is proven by our experience with its use.

It is possible to recommend the use of a similar design of the virtual laboratory for practical education in the field of e-commerce to other educational institutions. This could also confirm its suitability for such an education if applied in another institution or country.

When designing a virtual lab, it is important to think about what aspects of e-commerce will be emulated by this lab and which ones will be given maximum emphasis. In our case, the focus on e-communication, e-payments, and e-commerce management has proven to be very useful. When creating and applying a similar virtual laboratory to the educational process, it will be necessary to adapt it to the local conditions with appropriate adjustments. From a practical point of view, it is also advisable to use open-source solutions (such as OpenCart) for faster development of the laboratory and its possible adaptation to the required capabilities. The critical point is compatible interconnection of virtual laboratory's parts into a functioning entirety.

It would be useful to verify the benefits of using the virtual laboratory of electronic commerce by using a parallel control group that would not use a virtual laboratory in the training.

The results of such two different educational approaches could then indicate the effectiveness of our teaching method. This however could not be conducted in our case due to administrative rules valid in our institution.

Furthermore, even other design of virtual laboratory of electronic commerce might be constructed, tested and used within the educational process in other respective local conditions and higher education institutional curricula.

Our virtual e-commerce lab is used and adjusted every year to changing legislative conditions and technologies. Its current form is applicable to current conditions in Slovakia and is not universally transferable to any legal or technological environment without proper changes.

Our research also focused on participants' feedback and self-assessment. It was not designed to use a parallel control group that would undergo the training without the use of a virtual laboratory. This was not allowed by the curriculum and approved syllabus of our institute. The results could thus be distorted and their validity would be confirmed by the deployment of our laboratory for training in another institution, another country, or another technological and legislative environment.

Furthermore, any other form of measuring students' improvement in skills and knowledge within the area of electronic commerce might be employed to achieve more detailed results of learning gains.

In addition to that, other forms of electronic commerce might be emulated using specifically adjusted forms of various virtual laboratories of electronic commerce to improve students' knowledge, skills, and experience with particular form of electronic commerce.

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