Project-based Learning in the University Course and its Effectiveness

Dana Paľová, Martin Vejačka

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

Abstract –The effusively theoretical education belongs to the highly important problems within the area of education. Achievement of practical experience within the studied field improves students' knowledge and skills. This is similarly valid in the field of business informatics, where students can deepen their knowledge by developing a practical project, which is a form of project-based learning. The article aims to present how methods of project-based learning can be implemented in the business informatics university course. The educational process' effectiveness in the university course is measured using learning gains measures in the available periods. Comparison of the learning gains with project-based learning and without them shows improvement in the effectiveness of the educational process.

Keywords **– project-based learning, business informatics course, learning gain, effectiveness of educational process.**

1. Introduction

University education is an important part of the educational system, culture, public prosperity, and economic development around the world.

Higher education institutions must be able to train erudite graduates to raise the intellectual potential of the economy [1].

Therefore, organizations providing higher education have to examine new opportunities for improving the educational process to improve the abilities of future professionals, increasing their skills and competencies [2].

Education in the areas of business informatics, business process modeling, and information management is important for students of economics. Therefore, it should be included in the curricula of specializations in economics and finance because the ability of managers to process the information in digital form is very important for improving the effectiveness of management [1].

Currently, managers also have to play the role of information managers as they are often involved in the development or improvement of information systems (IS) in their enterprises [3]. Businesses are forced by the concurrence to constantly improve their products and services and in order to achieve that they should use all possibilities of information systems within their organizations.

A high-quality education in the business informatics and information management areas is, therefore, highly important for future managers in such positions. However, multiple authors ([2], [4], [5]) adduced that the university educational process frequently does not contain practical experience with problems from real everyday praxis. It is a challenge to provide practical experience with problem-solving projects to students within the educational process of a university course dedicated to business informatics. A suitable procedure to achieve this can be the implementation of methods of project-based learning (PBL).

2. Literature Review

Current students have already been born into the world with digital ICTs around them, as they are digital natives. So the usage of ICTs in everyday life is natural for them. Students also expect ICTs to be a component part of the educational process. Brown

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Corresponding author: Martin Vejačka,
Faculty of Economics, Technical University of Košice, Košice, Slovakia.
Email: martin.vejacka@tuke.sk

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[6] identified that ICTs are an essential part of the social life of the current young generation. ICTs also change their perception of learning, behavior, and life in general. Therefore, also the process of their education should be designed concerning their dependency on ICTs. Digital youth spends around 6.5 hours using ICT for various purposes, like instant messaging, browsing social media, listening to music, watching videos, or creating their own media content [7]. In addition, they are confident in ICTs, oriented toward groups, and risk-taking. International Education Advisory Board [8], considering these characteristics of the current student generation, identified the following requirements for learning design:

Patience - students should have the possibility to recreate tasks (even repeatedly). Students are ready to learn from mistakes and therefore, it is important to give them a chance multiple times until they are successful [8].

Clear goals - the learning objectives must be well-defined in advance. Realistic and clear conditions for successfully finishing the learning process should be provided at the start of the course. Everybody should have the same criteria for successful accomplishment, no matter the way or time needed to complete the objectives [8].

Change - learning goals might be divided into smaller ones. This teaches students time management and achieving goals by dividing larger tasks.

Tracking - students might overview their progress at any stage of the project development or at any other time during the educational process within the course. This allows students to track their path while reaching their learning goals [8].

Team play - assignments are finished, assessed, and revised in the groups of the course participants. This allows students to identify their strengths and weaknesses and to disclose their individuality and independence [8].

Patterns – meaning the learning environment must make sense for the learners. Furthermore, they learn to critically think, make rational decisions and identify patterns within the educational process [8].

Immediate consequences - lecturers provide timely feedback and valuation on each possible partial task. So students can easily identify, what is working and what is not for them [8].

Personalization - students may follow their learning goals by playing different roles to discover their strengths [8].

One of the most appropriate methods of educating the young digital natives is Project-Based Learning (PBL). Multiple authors investigate and identify the principles of project-based learning [9]. It is oriented toward students and supports the personalization of their study process [10]. Learners should elaborate on realistic projects during a specified time period, to acquire, sharpen and demonstrate their skills and knowledge. This shows students how their knowledge and skills can be implemented in praxis. [11].

Students might be grouped to encourage their collaborative learning and project-based learning is one of the forms of collaborative learning. When using PBL principles within the educational process, all the learners have to contribute to collective achievement. PBL includes also some features of experiential learning whereas conscious involvement and feedback are vital [12]. The educational process contains the application of the earlier knowledge and encourages discussion within the teams of students [13]. This can contribute to the increase in students' interest in education [14]. PBL might also encourage the creativity of students as well as teachers. The context of learning, when using project-based learning principles, is achieved by solving realistic problems from genuine practices [15]. In addition to that, students, while working on a practical project, expand the perspective of their previous knowledge and further develop communication and problem-solving skills [16]. Moreover, the components of cooperative learning motivate learners to help and support each other during the learning process [17] and also to boost their involvement, motivation, and engagement in the educational process [18].

Any project solved within the university course utilizing Project-Based Learning methods ought to take into account the following principles:

Challenging problem or question - the complexity of the problem makes studying more beneficial for learners, while they are to use more of their understanding and abilities to solve the problem [19].

Authenticity - the problem solved in the project should be an authentic real-life issue. Its solution should use real processes, standards, and tools. The basic principle is that the project should express the personal interests and concerns of a particular student [19].

Reflection – lecturer and students together reflect on work done by the students already and identify difficulties and suggest possible ways of overcoming them. This deepens students' knowledge gained and gives them an outline of how it can be applied even outside the project [19].

Sustained inquiry - students' peers and/or their lecturers should give feedback on their achieved results and gathered information [19].

Student voice and choice - students should obtain just the definition of the project but the preference of methods used for project processing should be subject to the student's choice [19].

Revision and critique - constructive feedback should be given during the development of the

project. Students should experience getting and also giving feedback on their ongoing projects as it is done in real-world projects. Feedback from experts from the praxis in the given is also highly desirable [19].

Public product - rises motivation of students to work harder, as their project's final results will be presented to the audience comprising of their colleagues [19].

The article focuses on the implementation of mentioned project-based learning methods and principles into the course of informatics for students of economics at our university and on measuring its effectiveness in comparison with the previous form of the course without the PBL methods.

3. The Course

Informatics II is the mandatory subject provided during the second semester of the bachelor's studies at our faculty. This course is provided for students of the Finance, banking, and investments study branch. The basic goal of the subject is to acquaint students with the field of business informatics, which they will meet in their future praxis. The content and the focus of this course are based on the skills and knowledge in the field of ICT the students already have from the first course – Informatics I and from their studies in lower levels of education [20].

The main topics of the Informatics II course include:

Basics of business informatics - gives the overview of various business information systems (e.g. supply chain management systems, ERP systems, CMS or business intelligence systems, etc.).

Data analysis in business applications - shows various types of business data, their usage, and work with them.

Business process modeling (BPM) - this part of the course is dedicated to processes within the company and to the procedures of data management and modeling with the aim to improve business processes.

Tools for processing business data - represent information and communication technology tools that are dedicated to data processing and process modeling. In this section of the course ARIS Express, MS Excel, and MS Access are showcased and used.

Trends of business informatics – this part shortly overviews the new technologies and their potential benefits for businesses.

Economic aspects of business informatics – in this part of the course, the students are acquainted with how ICTs impact the economic characteristics of the business.

The course is taught using both the face-to-face form and also using online learning. Face-to-face learning is implemented in the lectures, where the learners get theoretical information. Then, it is applied within practical labs, where they solve real-world problems using theoretical knowledge already gathered. The online learning part is performed using Learning Management System (LMS) Moodle, which is used for publishing learning materials, information, self-study assignments, self-testing tasks, and also for uploading semestral projects. The semestral project is a part of the final evaluation. LMS Moodle also gives a possibility for students to chat, do some online testing, give feedback on lectures, and also allows two-way communication with lecturers.

The final evaluation within the Informatics II course consists of several parts: a test of theoretical knowledge and a semestral project, the evaluation of which consists of the evaluation of quality, scope, the relevance of submitted outputs, evaluation the level of mutual cooperation, and subsequent professional discussion on the topic of the semester project.

The semestral project is the main utilization of project-based learning methods within the course of Informatics II. The main task is to create a simple information system in the environment of MS Access on the basis of predefined user requirements. Therefore, the basic task of students is to simulate the real process of entering requirements, creating models, and implementing a miniature information system with subsequent evaluation by the customer.

The student assumes the role of manager (or another responsible employee) of a company, organization, or institution that has a problem with maintaining information in paper (or other) form and wants to switch to an electronic version of information management. The information system (IS) should help you solve this problem.

As part of the task assignment, a student must identify the problems that the proposed IS can solve and (through the formulation of user requirements) design the parts and functions of the mentioned IS. In the future, these requirements will serve as a springboard for information technology (IT) specialists during the implementation of the proposed IS (which will be another student).

The most common problem, during the development of the semestral project, is the definition of correct and clear requirements for IS. Each student is trying to create an IS core (MS Access database) based on requirements defined by their peer in the documentation part of the project. During this stage, students find out (based on the feedback from the creator of IS), how realistic (or unrealistic) were their requirements within the formulation stage. This practical experience then

helps students to realize what they want from software or information system and how to clearly define it in praxis.

When working on the project students are required to form a pair (two-member team). Students have to think about the area in which they want to prepare their project and gather data. The topic of the project must be reported through the LMS Moodle with a short description of how it could improve or simplify the processing of existing data. Then each student prepares the formulation of user requirements on the proposed IS and uploads it. Another member of the team studies and evaluates these requirements, considering mainly if it is possible to create a process model and database. Implementing acquired knowledge on process modeling students prepare a model of a process within their proposed information system. Similarly, students create a simple database using MS Access which represents a substantial part of IS. If user requirements are difficult to implement or meaningless in the database, this discrepancy should be presented in the final project defense. The created process model in ARIS Express software and database are submitted through the LMS Moodle and are also evaluated by the second member of the team. The final evaluation also consists assessment from the lecturer during the defense of the project as a part of the final exam.

Students should not try to create a model of all processes in a large company, but rather focus on smaller processes and solve only partial problems. Any attempt to reform an extensive information system would be far beyond the extent of the course project and students would have problems modeling and implementing it.

When students are preparing documentation of the proposed information system, they must consider the firm's information requirements, ongoing processes in the company, and people's readiness to master new work methods within the IS.

This part of the project may also contain a short description of the considered process including:

- Formulation of the identified problem within an existing system
- Definition of users of the system
- List of the crucial fragments and functions of the IS
- Description of relations to existing systems
- Expected infrastructure requirements (HW, SW, communications, networks)
- System reliability and security requirements
- Estimated dates of implementation and estimation of the necessary costs for the introduction and operation of the IS
- The method of introducing the IS into the company's environment
- Documentation and training requirements
- IS perspectives, development, and maintenance

Furthermore, the use-case model should be prepared by course participants. It should be focused on the description of the basic functions of the proposed information system and the identification of the most significant data classes as a starting point for data analysis for the mini IS implementation itself. The system functionality requirements should contain a registry and short definition of actors, use-cases of information system, scripts for individual use-cases, and a use case diagram.

Then, based on the user requirements, the process model is prepared by the learners. The ARIS Express application is used for modeling and creating a process model. Also, an adequate description of the individual parts of the process is required. Students can choose from two types of diagrams for modeling - the EPC diagram or the BPMN diagram. This decision depends on the individual parts of the process.

According to the attributes of the classes specified in the user requirements, students create a sketch of the class diagram and a uniform structure of the data stored in the database.

Using theoretical knowledge, proposed user requirements, and process model, students create a database filled with test data. Within the database, students create queries that solve problems, or display information defined and requested through user requests.

The evaluation for the project includes the evaluation of these three main parts of the project – documentation of user requirements, process model, and database of small information system. It is, of course, a component of the general assessment of the course. There is also a score from the theoretical test and the assessment of the practical use of knowledge during the course.

So, students learn by doing during the elaboration of their project exactly according to the principles of PBL. During the project elaboration, students try out the basics of data processing, data analysis, business process modelling and creation of a simple information system. The effectiveness of PBL-founded education within our course should be measured by some means. Thanks to the availability of evaluation scores from years before the implementation of PBL principles, it is possible to compare the effectiveness of such education with years without the implementation of project-based learning.

4. Methodology

For comparison of the effectiveness of the education in the Informatics II course before the introduction of project-based learning, it was necessary to use comparable data. A reliable method

to allow such comparison is to use student grades or self-report scores of the same students over two (or more) points in time [21]. The availability of pre-course and post-course scores within the Informatics II course allowed us to use such comparison by expressing the learning gain of students and comparing them among the considered years. Generally, it is not simple to substantiate that a learning gain was caused by education in a particular course [22]. Mainly, due to possible parallel learning, maturation or retention. Additionally, it is hard to make a control group without an educational intervention [23]. However, there is consensus that the comparison of scores is a valid form of education effectiveness measuring in academic subjects [24].

Multiple authors adduced usage of class-average normalized gain for measuring the effectiveness of educational courses in various fields of study [25], [26]. Class-average normalized gain ⟨g⟩ is the proportion of the average achievement of the complete group of students to the maximal possible improvement. Arithmetically, it represents the proportion of the maximal possible pre-course score to post-course gain [22].

In the course Informatics II, there were pre-course and post-course tests scores available during the recent four years of the subject provision. Therefore, assessment and comparing of pre-course and post-course grades employing learning gain measures might be a suitable way of evaluating the effectiveness of the educational process in this course. To measure this effectiveness, absolute gain, relative gain, and class average normalized gain were employed. These are standard methods used in our institution to measure education effectiveness in appropriate courses [27].

Average gain (g_{avg}) is expressed as the subtraction of the mean post-course score from the mean pre-course score acquired by course participants in a given period (1).

$$g_{avg} = \text{Avg post-course score} - \text{Avg pre-course score} \quad (1)$$

Absolute gain (g_{abs}) is enumerated as the proportion of average gain and maximum score possible in the examination (2).

$$g_{abs} = \text{Avg gain} / \text{Maximum score achievable} \quad (2)$$

Relative gain (g_{rel}) expresses the increase in the results of students compared to their earlier scores and it is enumerated as average gain divided by average pre-course score (3).

$$g_{rel} = \text{Avg gain} / \text{Avg pre-course score} \quad (3)$$

Then, the class average normalized gain ⟨g⟩ can be expressed as the average gain divided by the maximum possible gain (4). The maximum possible gain can be calculated as the average pre-course result subtracted from the maximum score achievable (100 points).

$$\langle g \rangle = \text{Avg gain} / (100 - \text{Avg pre-course score}) \quad (4)$$

These measures were used to express the education effectiveness in the Informatics II course.

5. Results

For determination of the effectiveness of the project-based learning approach within the course of Informatics II, the results of students from the year before the introduction of PBL methods (2019) and the years with PBL implemented (from 2020 to 2022) were compared.

The test at the course's end (source of post-course scores) is part of the final exam in the Informatics II course. In selected years (2019 – 2022), there were available also pre-course scores from the tests based on similar knowledge from the same areas of Informatics. Tests were conducted electronically using the environment of LMS Moodle. These tests were compulsory for the subject graduates, so all students successfully graduating from the course were included in the sample. The tests comprised 20 inquiries accidentally chosen from 250 inquiries arranged by teachers. The inquiries from the areas of study in the Informatics II course were prepared to be of similar difficulty on average. The following Table 1 contains the comparison of scores over the considered years.

Table 1. Comparison of pre-course and post-course scores in the years 2019 - 2022

Year	N	Pre-course scores	Post-course scores	p value	Absolute gain (g_{abs})	Relative gain (g_{rel})	Class average normalized gain ⟨g⟩
2019	149	55.82% ± 10.24%	69.73% ± 12.33%	0.016	13.91%	24.92%	31.48%
2020	137	57.59% ± 12.10%	72.53% ± 12.64%	0.013	14.94%	25.94%	35.23%
2021	138	56.27% ± 13.14%	72.17% ± 11.14%	0.029	15.90%	28.26%	36.36%
2022	128	55.71% ± 11.38%	71.97% ± 10.92%	0.028	16.26%	29.19%	36.71%
Total	552	56.35% ± 11.72%	71.60% ± 11.76%	0.022	15.25%	27.08%	34.95%

The maximum score in the tests was 100%. The data on the scores obtained by the students were gathered from consecutive 4 years (2019-2022) of the Informatics II course provision. In every period, more than 120 tests were collected (in both moments distinctly). This exceeds the minimum criteria for the relevant sample size, adduced by the Hair Jr et al. [28] being 50 (preferred over 100 observations) for most research situations.

In the year 2019 project-based learning methods were not implemented in the Informatics II course. Furthermore, it was the period before the Covid-19 pandemic, therefore the classes were committed fully in live attendance form.

In the years 2020 and 2021 the principles of project-based learning, in the form stated before, were already implemented in the course of Informatics II. The provision of the course of Informatics II was in these years also influenced by the Covid-19 pandemic prevention procedures. It caused that live attendance classes might not be committed and the course was provided in a fully online form for all participants. Lectures were conducted using the Microsoft Teams application. In addition, plenty of video tutorials and text materials were supplemented within LMS Moodle to support the self-learning of the students. Furthermore, students could consult the course topics with lecturers using video calls, online chats, or emails.

In total, 552 eligible tests were gathered in both: the pre-course and post-course groups of scores in the period from 2019 to 2022. There were included only the results in the cases where they were available for both pre-course and post-course tests to avoid distortion of results. Overall, the average test score increased from 56.35% (±11.72%) for the pre-course test to the level of 71.60% (± 11.76%) ($p = 0.022$) average result post-course test score. In total absolute gain was 15.25% and the relative gain reached 27.08%. Class average normalized gain ⟨g⟩, serving as the main measure in our analysis, was at the level of 34.95%.

The educational process is regarded as effective if the class average normalized gain is higher than 30% as stated by [29] or [30]. That level of effectiveness was exceeded in total and also in every individual period, suggesting that the educational process in the course of Informatics II is effective.

In 2019, the average score increased substantially from 55.82% (±10.24%) for a pre-course test result to the score of 69.73% (± 12.33%) ($p = 0.016$) achieved on average in the post-course test. The absolute gain in 2019 reached a level of 13.91% and the relative gain a level of 24.92%. The class average normalized gain ⟨g⟩ achieved the level of 31.48%. It suggests that education in the course of Informatics II was effective even before the introduction of project-based learning methods into it.

In 2020, the average test score risen from 57.79% (±12.10%) of the pre-course results up to 72.53% (± 12.64%) ($p = 0.013$) for the post-course test. The absolute gain reached a level of 14.94% and the relative gain of 25.94% in the year 2020. The class average normalized gain ⟨g⟩ was 35.23%. This indicates that in the first year of the implementation of project-based learning (2020), the effectiveness of education increased despite complications in the education process connected with the Coivd-19 pandemic.

The 2021's average test score raised from 56.27% (±13.14%) from the pre-course test up to the level of 72.17% (± 11.14%) ($p = 0.029$) within the post-course test. The absolute gain in this year was 15.90% and the relative gain was 28.26%. The class average normalized gain ⟨g⟩ reached the level of 36.36%. Also, the year 2021 suggests that the level of educational effectiveness is higher than before the introduction of PBL into the course. This year was also affected by Covid-19 prevention measures.

In the year 2022, the average test score increased from 55.71% (±11.38%) as the pre-course result to 71.97% (± 10.92%) ($p = 0.028$) for the post-course score. In this year, the absolute gain reached 16.26% and the relative gain was 29.19%. The class average normalized gain ⟨g⟩ reached level of 36.71%, which was the highest level in the considered period. This year was not affected by the pandemic and project-based learning methods were present in the education process of the course.

Hence, the comparison of the years (2020-2022) with introduced PBL methods in the educational process against the year before this introduction (2019) shows an increase in the class average normalized gain (average increase of 4.62 points in final class average normalized gain). This suggests that the implementation of PBL methods into the educational process of the Informatics II course even increased its effectiveness.

At the end of the course, the feedback survey from the students on the course was realized each year. The feedback survey was realized through the environment of LMS Moodle and it was mandatory for the students after finishing the course. The following results are from the latest feedback survey conducted in 2022.

In general, students adduced that the Informatics II course is demanding but rewarding for their expected future praxis. Over 90 percent of responding students were overall satisfied with the Informatics II course (around 62 percent were very satisfied). Almost 76 percent of respondents were fully satisfied with the content of the Informatics II course. In the 93 percent of answers, students adduced that the course fulfilled their expectations. Slightly above 90 percent of students highly evaluated the approach of lecturers to

the students and the educational process in the course in general. Approximately 85 percent of the responding students stated that abilities trained in the course are needed for their upcoming praxis. Over 74 percent of them would recommend the course to the other students.

Over 63 percent of students esteemed the opportunity to deepen their skills and knowledge by elaborating on the course project. Almost 71 percent appreciated the high level of information quality on project elaboration and the related tasks. Around 51 percent of respondents welcomed the accent on the creation of information systems (including the creation of user requirements, process modeling, and creation of a small database). Around 97 percent of students confirmed that the project elaboration allowed them to acquire new knowledge in the field of business informatics.

Over 88 percent of students welcomed the availability of video tutorials for the course topics as supporting material available to them in LMS Moodle. These tutorials were prepared as help for students during the Covid-19 pandemic years. Over 76 percent of the responding students appreciated also lectures by experts from practice.

Slightly over half of students (almost 52 percent) suggested increasing the weight of the semestral project in their overall evaluation at the end of the course to some extent. Almost 70 percent of respondents would welcome even more lectures led by experts from practice. Almost 64 percent of students would suggest preparing video tutorials for all topics within the course. Most of these suggestions are to be incorporated (if possible and suitable to the character of the course) in the next iterations of the Informatics II course.

6. Conclusion

The course Informatics II provides education in selected topics of business informatics to the students of economics at our university. The course is constantly improved each year to reflect the changes in the field of business informatics. In recent years it includes in its educational process also the methods of project-based learning as its participants had to improve or elaborate a simple economic information system. So, the course participants gain also practical experience with the formulation of user requirements, process modeling, and creation of a database. During the project evaluation, they also gain practical experience with ARIS express modeling software and MS Access software.

The effectiveness of the learning in the course of Informatics II was investigated. Relative gain, absolute gain, and class average normalized gain measures were employed to express the learning gains of students as the pre-course and post-course scores were available for four years from 2019 to 2022. The comparison contained the year 2019 when the project-based learning methods were not used in the course. In the years 2020, 2021, and 2022 the course already included PBL elements in the educational process. Additionally, the methods of education during the years 2020 and 2021 were influenced by the pandemic of Covid-19. However, in all investigated periods class average learning gains indicated an effective educational process. After the introduction of project-based learning principles, the effectiveness of the educational process increased as the class average learning gain scored on average 4.62 more points in total. The Covid-19 pandemic did not affect this increment of learning gain.

The feedback on the course was also gathered and its results indicated a high level of satisfaction with the education in the course Informatics II. Several suggestions from students for further improvements to the course were also gathered in the feedback survey and they will serve as a basis for amendments in the course in the following years.

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