TRANSFORMATIVE EDUCATION WITH AGILE PROJECT MANAGEMENT AND PROJECT-BASED LEARNING

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Abstract: The present trend of automation and digitization of jobs has made the skills gap even more pronounced, indicating that graduates are not sufficiently prepared for the challenges they will face in their careers. The educational process needs to adapt quickly to the demands made by employers and the job market. Learning tasks, assignments, and activities should mimic the practice environment as far as possible, to best prepare students for practice. One of the best approaches appears to be the incorporation of agile project management techniques and project-based learning into the educational process. The primary aim of this research is to examine the effects of implementing agile management techniques and project-based learning into education on students' skill sets and performance improvement rates. The activities and results that the students produced throughout the semester were gathered and assessed over two academic years. The course feedback was also gathered to investigate students' opinions about the course and their involvement during the semester. An exploratory study was conducted in order to achieve the results. The influence of implemented innovations on the course was addressed, and the acquired outcomes were contrasted and appraised.

Keywords: education innovation, agile techniques, SCRUM, project-based learning, skills gap, higher education

1 Introduction

Changes in the world, in human society and the world of technology, are also creating a need for change in education. Due to constant geopolitical and climatic changes, it is therefore important that educational activities meet the challenges for achieving Education for Sustainable Development (UNESCO, 2020) to educate a young generation capable of responding to the above-mentioned changes in society and on Earth at all. The basic principle of survival will be cooperation therefore becomes important the introduction of how to solve various problems in different areas within a small team into the education process. One of the benefits is, that students could gain experience of how to do this in a safe (they do not have to worry about possible failure) and controlled, secure environment (where the teacher is always available in case of problems and guides them through a crisis and where they do not have to worry about the consequences of an incorrectly chosen solution, failure of the proposed solution, etc.) while they could develop their talents and skills. To help them the teacher has several tools and methods to achieve this objective, but most often used is project-based learning. Project-based learning provides a space for hard but also soft skills development of the students. By working in small groups communication and close collaboration, bringing individual talents together, solution-focus, sharing knowledge, positive attitude, respect, etc. is enhanced and trained (Mickan & Rodger, 2000). Commitment, focus, openness, respect, and courage are the core values of the SCRUM method (Scrum Guides, 2020) - agile project management - thanks to which it seems to be a suitable method for education.

This paper, therefore, presents how SCRUM is implemented in education at our educational institution. Our basic motivation was to implement an innovative method of team management into a course focusing on the area of business informatics. As we have already implemented the project-based learning method in the past in this course, where students worked on solving problems in micro-teams, we were interested in whether the implementation of the SCRUM method will bring the development of team skills in our course and whether these changes will be reflected in the overall assessment of students. In this paper, we present our method of implementation of project-based learning enriched by the SCRUM method and compare the results with the results from the previous year, when only the project-based learning method was implemented. Based on the review of the published research results and our implemented innovation using PBL methods with SCRUM, we defined the following research questions: How will the introduction of PBL and SCRUM in the classroom affect students' outcomes? Will the introduction of these methods have an impact on the development of students' soft skills?

We tried to find answers to these questions by using and analyzing different data that can be collected during the course implementation and after the course completion. The comparison of the results obtained by us, as well as the results of other published works (Krajcik & Shin, 2014; Ralph, 2015; Torres, Shiraman & Ortiz, 2019), led us to describe the benefits, shortcomings as well and challenges for further innovations in education using the mentioned methods. Our main aim is not to generalize achieved results but to understand the cases better.

2 Literature review

Technology and automation are readily available, prompting employers to have different needs not only for the younger generation but also for the active workforce. It is expected, that by 2030, around 30-40% of the workforce in developed countries will require skills upgrading or complete skill set transformation (Hancock et al., 2020). The skill gap is growing and employers struggle with a shortage of suitable labor every year. The importance of soft skills and their scarcity is increasingly becoming evident. The incorporation of soft skills development into university education influences the employability of young people, the competitiveness of enterprises at the national and international level, which means the economic development of countries also in the global dimension (UNESCO, 2015).

Soft skills (a group of socio-psychological skills) enable successful integration and participation in the work process (e.g. analytical, predictive, and creative thinking, communication, the ability to cooperate and negotiate, the desire to acquire new knowledge and self-development, self-organization, skill lines, developed social and emotional intelligence etc.) (Panfilova & Larchenko, 2021).

Soft skills could be developed through formal, non-formal, and informal activities performed with various tools like mini-curricula; programs, workshops and labs; training sessions; projects (internal project works, external cooperation projects etc.); internal and external competitions; cycles of seminars (face to face lessons) and/or colloquia (guest speakers); company visits, journeys (study tours), internship and on the job training; individual or group tasks/learning based on practical activities. One of the important factors is to bring students together in a common but also competitive environment where they can learn from each other and through exposure to authentic, complex, and real-life problems.

Laboissiere and Mourshed (2017) listed the effective training components as programs engaging participants and delivering the exact skills required for each profession, curricula emphasizing practical tasks, regular testing and assessing during the course, and employing different ways of delivering necessary instructions to students. By using the two following described approaches (Project-based learning and Agile techniques) it is possible to improve the effectiveness of the educational process.

2.1 Project-based Learning

Project-based learning (PBL) is not a new method or approach in education. Already in 1974, it was implemented at Aalborg University, Denmark (Luxhøsj and Hansen, 1996). Due to its many advantages, this method is often used at all levels of education, including primary and secondary schools, as well as universities (e.g. Affandi & Sukyadi, 2016; Costa-Silva et al., 2018; Mou, 2019). PBL Works (2022) defined Project-based

learning as a teaching method in which students gain knowledge and skills by working for an extended period to investigate and respond to an authentic, engaging, and complex question, problem, or challenge. What is important to mention, is the main principle is that the project is closely connected to the curriculum learned (PBLWorks, 2022).

Using the PBL teachers get the tool for reaching more engaged students because students see the meaning of course content and its usability in real-world problems or situations solution. Participating in the PBL students develop their hard but also soft skills (Condliffe et al., 2017; Parker et al., 2013). There are known six 7 essential project design elements that need to be delivered: the level of challenge must be appropriate, the project must be concerned with meaningful and real-world problems, students are involved in posing questions, finding resources, applying information, students making decisions about the project and they can express their own ideas and voice, students and teachers reflect on the effectiveness of learning and project activities and finally students give, receive and apply feedback to improve their process and products (Krajcik & Shin, 2014; Miller & Krajcik, 2019). In this way, students besides developing their technical and expertise skills develop the skills needed for project work, the 21st-century capabilities (Häkkinen et. al., 2017). Lampert (2010) describes PBL as an approach based on the assumption, that students are competent to use a wide range of resources to create meaning and new insights and products.

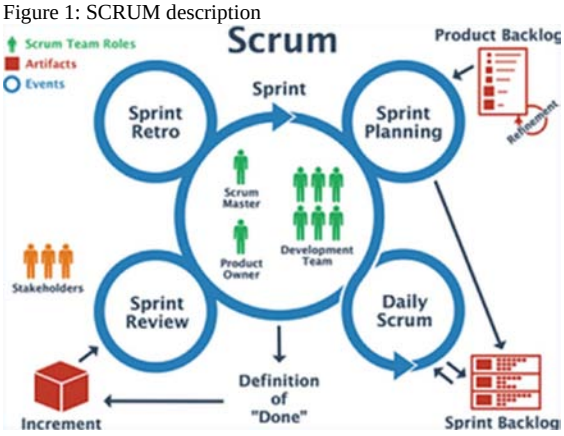
The PBL approach is widely used by many universities and its effectiveness is already researched. Zhang & Ma (2023) presented a study of the impact of PBL and realized, that the effectiveness of the method is influenced by many variables like country region, subject area, type of course, academic period, group size, and experimental period. They realized that using PBL engages the higher education students of engineering and technology subjects applied in laboratory classes, in small groups of 4-5 students, and for a duration of 9-18 weeks. Almulla (2020) investigated the effectiveness of using this approach to engage students in learning. The collected data analysis has demonstrated a positive effect engagement of higher education students especially in STEM education (Ralph, 2015), as well as other similar studies (Häkkinen et al., 2017; Kokotsaki et al., 2016).

Viro et al. (2020) in their research realised, that the development of teamwork skills was found the most important characteristic of the BPL by the teachers. In the background of this attractive method, most teachers acknowledge the technical issues and setting learning goals as collaboration, time, and organization of the projects as significant challenges in the implementation and realization process (Viro et al., 2020; Aksela & Haatainen; 2019). These are the reasons, why teachers prefer to use the PBL outside of regular lessons.

2.2 SCRUM

Agile management methods were declared for the first time as part of "The Agile Manifesto" by Beck (2001) and related to changes in the field of project management during the development of software that meets the client's requirements. Their advantage is that they can react better to the frequent changes present in practical software design. The most frequently used agile methods are Kanban, eXtreme Programming (XP), SCRUM, lean software development, feature-driven development (FDD), and crystal methodologies (Dingsøyr et al., 2012). Agile methods are a designation for various non-traditional frameworks, methods, and approaches. Their advantage is flexibility, transparency, quality enhancement, project team, stakeholder engagement, etc. One of the methods that has found application in a wide range of areas, especially innovation and education, is SCRUM. The main ideas and principles of this method are focus on the customer, continuous improvement, visual management, flow of work, and waste reduction. SCRUM could be described by three groups of components (Figure 1): SCRUM Team Roles (SCRUM Master, Product Owner, and Development Team), Artifacts (Product Backlog, Sprint Backlog, and Increment), and Events (Sprint, Sprint planning, Daily SCRUM, Sprint Review, and Sprint Retrospective).

Figure 1: SCRUM description



Source: Ravulapalli, 2018.

The SCRUM methodology was modified to EduScrum to copy the needs and specifics of an educational process. This approach has already been applied in various educational institutions, in the education of various subjects. The main idea behind SCRUM theory is based on three pillars: transparency, inspection, and adaptation (Scrum Guides, 2020). Transparency ensures that all tasks, processes, and their fulfillment are always visible to all team members and to the people for whom the product is created.

SCRUM was, similarly as in practice, also in education, first implemented in software engineering education including various approaches such as SCRUM-X (Lee, 2016), SCRUM Game (Rodriguez et al., 2022), use of LEGO-based simulation game (Steghöfer et al., 2017; Bourdeau et al., 2021) education gamification using Minecraft (Schäfer, 2017), etc., followed by other STEM subjects such as mathematics (Duvall, Hutchings, & Kleckner, 2017), currently, it is also implemented in other interdisciplinary fields (Gestwicki & McNely, 2016). Rodriguez, Soria, and Campo (2016) researched significant differences in positive shifts in students' activity level, positive attitude towards the SCRUM-based project management, and improvement in students' soft skills level.

Based on research, it is possible to describe the benefits of using SCRUM in education:

- Positive impact on the development of students' soft skills, i.e. oral presentation, punctuality, leadership, decision-making, time planning, leadership, and responsibility (Valentin et al., 2015).
- Higher students' engagement, because it helps to clarify the meaning of learned topics (Cubric, 2013).
- More frequent communication among students in teams and at the same time with the teacher who gives feedback to the team more often (Cubric, 2013).

The SCRUM is mostly used with project-based learning, where the main goal is to produce the final product (the project-based method outcome) produced by simulating teamwork in small groups (based on the agile approach) (Paez, 2017). Due to the fact, that SCRUM is implemented in different forms of education, its implementation is also subject to different modifications related to the principles of education organization at a given educational institution or level of education. Muller-Amthor et al. (2020) indicate several possible modifications for Higher Education (HE): Learning goals are written as User Stories listed in the Product Backlog, Sprints are spanned a week or longer time depending on the lesson frequencies, the SCRUM-HE Daily Scrums could take place without physical

presence, etc. When implementing the traditional PBL approach, students often wait until the last minute to work on a project, which is reflected in the lower quality of the performances (Kudikyala & Dulhare, 2015). Villavicencio et al. (2017) reported that the introduction of the SCRUM has the potential to eliminate this deficiency because it is necessary to work on the project continuously during the separate sprints and their continuous evaluation. The other benefit is the fact that the SCRUM master is a student who manages the team, and a teacher acts just as guidance to avoid the "loss" of the students and their helplessness (Pears & Daniels, 2010). This leads to more effective self-organization of the learning process as well as to the development of soft skills.

We also encountered the above-mentioned problems, so we decided to implement the SCRUM approach and followed by analyzing different data to check if it could be beneficial for our project-based learning.

3 Innovation of Education in the Field of Business Informatics

Course Informatics II is a compulsory subject taught in the first year of the bachelor's degree. The course aims to acquaint students with business informatics and concepts related to this area, data in the company, i.e. show how and where the data is generated, and how it is processed and used for management within the framework of the individual levels of management. Within the course, students learn about the principles and methods of process and data modeling and their interrelationships, the possibilities of implementing these methods in the environment of real companies, and learn to practically create basic models used during the design of business information strategy. As part of the course, students are accompanied by work in various applications, which show them the individual stages of working with data within the enterprise.

The course is realized in person by a combination of lectures (focused on the explanation of basic concepts and terminology, interspersed with lectures by people from practice, who directly point to the use of the acquired knowledge in the practical environment of the company) and practical exercises in PC labs (aimed to develop practical hard skills focused on the solution of individual partial practical problems, formulated in such a way that can apply the knowledge gained during lectures or by studying online study materials). These face-to-face lessons are more concerned with achieving hard skills.

Besides traditional lectures and lessons, students must participate in semestral projects (SP), whose objective is to design some kind of innovation within a virtual company by using its data. The semestral projects are targeted at soft skills development (like analytical, predictive, and creative thinking, communication, the ability to cooperate and negotiate, the desire to acquire new knowledge and self-development, self-organization, skill lines, developed social and emotional intelligence, and much more).

The semestral project's objective is to develop an implementation of a small information system (IS) based on the end user (client) requirements. This project was solved in pairs (in 2021/2022), where the partial roles are switched during the solution. The main task is to simulate the real process of specifying requirements, creating models, and implementing a mini IS with subsequent evaluation by the client. The process of work on the projects could be described by the waterfall project lifecycle. At first, students play the role of a manager (or other 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. As part of the assignment, they must identify the problems that the proposed IS can solve and, through the formulation of user requirements, propose the parts and functions of said IS. These requirements will serve as a springboard for future IT (information technology) specialists during the implementation of your desired IS (which is a colleague from his/her pair).
What is important to mention is that students have no previous experience in industrial project management and software engineering. The semestral project is an activity outside the school, and it lasts the whole semester (i.e. 13 weeks). The implementation of the semestral project itself was preceded by:

- introduction to SP and its objectives (not only the expected outcomes description but also the education objectives),
- a general introduction to the organization and project management,
- an overview of approaches to project management in general,
- external presentations from industrial project managers (published on YouTube channel),
- a self-study phase followed by regular discussions (10 min. at the end of every face-to-face lecture, online discussions).

The preparatory phase, which takes about 2 weeks, was followed by the implementation phase when students worked on the projects independently. During this phase, they constantly had the tutor and their colleagues at their disposal, with whom they could discuss any uncertainties and problems that arose. After 13 weeks they submitted their solutions to the LMS Moodle, where the assignments were presented to their mate auditory and evaluated by their randomly selected colleagues and the tutor.

As was already mentioned above, in the 2021/2022 iteration it was possible to describe the solution of the semestral project by the so-called waterfall principle of project management. In this case, the project and its solution gradually evolve over time, but it often happens that a student, due to lack of experience with a similar project and a given area of implementation, discovers the errors or shortages in the solution at the end of the semester, just before the deadline for submitting the solution itself. At that time, it was very difficult to redo the whole project in case of a serious error. Students highlighted this shortcoming as the most frequent reason for their failure. We already had positive feedback on the use of PBL in the educational process in the past, but the problem was often the lack of possibility to work in a team, poor time management, and inappropriate/unclear communication on the part of the assignor of the problem. This phenomenon was one of our motivations to improve the project itself and increase its positive effect on the students. The SCRUM method and its principles allow us to avoid the above-mentioned problem, allow students to discover their strengths and weaknesses, and to know how to use them when working in a team therefore, we decided to implement it in the project.

As mentioned above, agile techniques are more beneficial in the management of innovative projects, especially in the field of IT. Because we aim to develop a small information system for the chosen company in the year 2022/2023 we introduce the SCRUM method into the semestral project, which presents a real small IT project. Based on the research done by Fernandes et al. (2021), the SCRUM method helps a student to develop project assignments more smoothly and more clearly and effectively showing how to manage all necessary activities to succeed.

Because they are absolutely new in the field of Business Informatics, project management, and especially SCRUM, we prepared for them a special e-book devoted to the SCRUM approach and divided the semestral project outcomes based on the SCRUM terminology. The following roles have therefore been clearly defined in the framework of the project solution:

- Product owner – teacher responsible for classroom planning, the definition of the roles, and construction of work so that students get understanding and meaningful learning. The teacher prepares the Product Backlog, the acceptance criteria, and other important information connected to the semestral project.
- SCRUM master - the member of the team elected by the other team members, responsible for eliminating the obstacles that arise during the sprint period. SCRUM master

was responsible also for communication with the Product Owner and for leading the meetings, task planning, communication management, etc.
- SCRUM team – students - team members cooperating on the semestral project solution.

Students had the opportunity to create teams at the beginning of the semester, but after the set deadline date, the teams were randomly generated. Each team worked on a project for a company (it could be fictional, or they could be inspired by a real operating company). The role of the teacher (as a product owner) was to consult with the SCRUM masters during the solution time and point out the possibilities of using the individual topics discussed in the framework of face-to-face education. SCRUM team is empowered to self-organize. During the semester, SCRUM masters had regular consultations with the Product Owner, who was a teacher. Since we left the SCRUM organization in the students' hands, they could define their own SCRUM sprints and their length as well as other project management parameters.

The three main parts of the SCRUM Theory need to be filled: transparency, inspection, and adaptation. We have tried to implement all this in the framework of team management using the Trello application (Figure 2).

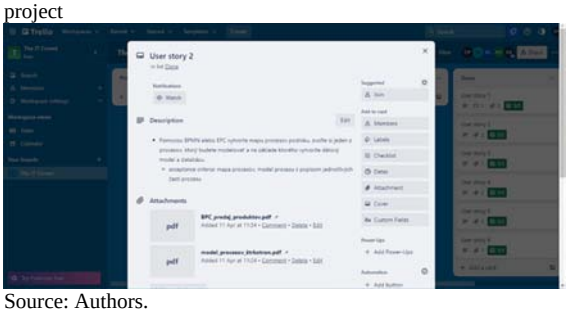
Figure 2: Example of one of SCRUM teams using the Trello application board for handling the project

Source: Authors.

As stated in (Scrum Guides, 2020), for the success of the method it is important to plan so-called SCRUM events, which should not last longer than one month. To ensure this, we have made the situation easier for the students by outlining the sequential tasks and their quantity. This way, they won't have to plan the solution from sprint planning to retrospective over a longer period during the semester. The product backlog was defined by the 6 user stories with acceptance criteria and had been defined by the teaching professor in his role as the product owner.

During the Sprint Review inspection, the teacher (Product Owner) checks the team's activity and particular draft versions of outcomes, and the existence of other team events within the Trello boards (Figure 3). In case of large deviations from the expected results, the SCRUM Master is informed and has the opportunity to discuss them with the Product Owner. The Product Owner proposes strategies to improve or rebuild the particular user story.

Figure 3: Example of partial solution of a user story of semestral project



Source: Authors.

The final evaluation of the semestral project took place in two ways - the quality of the outcomes was evaluated from the point of view of technology (i.e. the achieved value of hard skills) and at the same time, the students presented the summary information about their productions but also about the sprints and a retrospective on the whole course of their SCRUM teamwork (i.e. the development of soft skills). During this review team presents how the developed outcomes meet the acceptance criteria. The Product Owner is responsible for validating and evaluating the work and giving the feedback to the students (as points and also the verbal feedback and conclusion).

4 Methodology

This research was focused on monitoring and analyzing the success of PBL implementation and integration of the SCRUM method into PBL in the framework of the Informatics II course, which is taught in the first year of bachelor's degree studies. This paper aimed to analyze whether the introduction of the SCRUM method has a positive impact on the course of study and the results obtained by students. For the purpose of the study, we compared two years when PBL was implemented alone and then with SCRUM integration. We were interested in how course feedback would change, whether project work would be a greater contribution to the final course grade, and what benefits the students themselves identify. Based on the research we construct three main research questions:

1. How will the introduction of PBL and SCRUM in the semestral project affect students' outcomes?
2. Will the introduction of these methods have an impact on the development of students' soft skills?
3. Will students perceive the introduction of SCRUM positively?

To find out the actual situation, we analyzed the results of the students in the framework of assignments, and exams, and students' opinions gained thanks to the feedback. To be able to realize the research we need to collect the following data:

- Number of students and teams.
- Types of available outcomes and evaluation types,
- Evaluation of the course by students and teachers,
- Intermediate, partial, and final grades of the students.

All of these data are available in the university academic system and LMS Moodle which is used for learning process support, publication of important information for the students, and collecting students' assignments. These data were then used in the development of the big picture of the semestral project and its role in the subject as a whole.

In addition to quantitative data, we collected also qualitative data. We used questionnaires to obtain students' opinions, as they are also used in several other publications aimed at evaluating the benefits of the teaching methods. This is a similar approach as used in multiple other studies (e.g. Assaf, 2018; Beier et al., 2018; Almulla, 2020). We were especially interested in the students' opinions about the newly implemented SCRUM method. We collected students' views on the use of the SCRUM method in two ways: in the feedback session and then in the semestral project presentation, where students had to present a retrospective of their SCRUM (duration of the SCRUM sprint, positives/weaknesses, task distribution, project workload, team conflicts, difficulties, and solutions, etc.). Within the feedback framework, main questions were created on the MSLQ (Motivation and Learning Strategies Questionnaire) theory (Pintrich et al., 1991). Especially those concerned with motivation (intrinsic and extrinsic goal orientation, task value, control of learning beliefs) and learning strategies (time and study environment, peer learning, help-seeking). We used different types of questions in the feedback: closed and open-ended. Closed questions imposed the Likert scale, where students could indicate the level of their agreement (or disagreement) with some predefined statement related to a part

of the study that they had just completed. To avoid any errors and points of confusion, the feedback questionnaire and its composition were verified and validated by a psychologist and other colleagues participating in the course. At the same time, we pre-tested it on another, smaller group of students attending a similarly focused course.

The observations were carried out in two academic years (2021/2022 and 2022/2023), i.e. after the COVID-19 pandemic, when students returned back to school for full-time study and thus had approximately the same conditions for completing the course.

The study involved 195 students in the year 2021/2022 and 118 students in the year 2022/2023. These are first-year students of bachelor's degree in Finance, Banking, and Investment. As part of our study, we analyzed the SP assessments of all students who had worked on it throughout the semester. However, the evaluation of the SP was included in the final course evaluation. Those students who had not passed the credit exam could not participate in the feedback questionnaire. Because of this, only a certain percentage of students, specifically 67.18% in 2021/2022 and 82.20% in 2022/2023, were able to provide their opinions for our evaluation. As was mentioned above, students were divided into small teams while they were working on the SP. In the year 2021/2022 were divided into pairs and we have a total of 97 teams. In 2022/2023 we introduced the SCRUM method, and it was necessary to create more numerous teams as our goal was to support the soft skills of the team members. Based on the Scrum guide (EduScrum, 2020), we decided to create 24 teams of 4-5 members.

We evaluated the results obtained by the students after the course using statistical methods (normality of distribution tests, nonparametric tests, etc.). The results of the online questionnaire were used for exploratory analysis. Quantitative feedback results were obtained by calculating basic characteristics (frequencies, averages, etc.). Qualitative feedback results from open-ended responses were obtained through content analysis (Worthington & Whittaker, 2006; Krippendorff, 2019). Open-ended question answers, the data was analyzed by reducing its pre-defined categories, whilst also acknowledging the themes arising from the data (Cohen et al., 2007; Markula & Aksela, 2022). Based on the achieved results, we formulate the conclusions and challenges for further course improvement.

5 Results

As mentioned above, in the framework of the study we were interested in the impact of the introduction of the SCRUM method into PBL. Therefore, we compared the results of students in year groups where the semestral project was implemented using the PBL method and PBL enriched by SCRUM. After the initial processing of the obtained data, we found that the basic indicators (such as the number of successful graduates of the course) increased significantly. Since this phase of research, we did not analyze this phenomenon in depth in terms of identifying the influencing factors and their interplay.

The overall indicators show a positive trend. While in 2021/2022 only 67.18% of all students passed the practical test and 64.62% of students passed the subject overall, in 2022/2023 we see an increase in both indicators. Since the only change that has been introduced in the course is the implementation of the SCRUM method, it is possible to conclude that from a general point of view, this change has a positive benefit for the course. The most important difference is the need for teamwork in solving the project, which we assume has resulted in greater communication and cooperation among students in other aspects of the study of the subject. To be able to confirm this assumption, we have carried out a further examination of the collected data.

To compare the results of students taught using the SCRUM method and without it, the comparison between two iterations of the Informatics II course was conducted. As long as the SCRUM method was used in the development of the semestral project in 2023's iteration, only scores for the semestral project were considered. The comparison was conducted with the scores of the semestral project of the year's 2022 course iteration.

Following table (Tab. 1) presents the summary results we obtained in both years.

Tab. 1: Comparison of basic overview indicators of the subject

Indicator	Academic year 2021/2022	Academic year 2022/2023
Number of students	195	118
Number of students passing credit exam	131	97
Number of students passing the course	126	96
Percentage of students successfully passing the credit exam	67.18%	82.20%
Percentage of students successfully passing the course	64.62%	81.35%
Average credit exam evaluation value (max. score 40pt)	27.35 pt (68.38%)	26.84 pt (67.11%)
Average final exam evaluation value (max. score 60pt)	43.20 pt (72.00%)	46.11 pt (76.84%)
Average overall course final evaluation value (max. score 100pt)	70.63 pt (70.63%)	72.94 pt (72.94%)

Source: Authors.

In 2022 semestral project was evaluated with a maximum of 30 points and 195 students managed to elaborate on the semestral project. These scores were adjusted to the same basis as the maximum score of 2023, which was 40 points, by multiplication by a value of 1.33. The number of relevant students' semestral projects in the year 2023 was 118. The adjusted mean score for the 2022's semestral project was 21.95 points (SD=10.101) and the mean score for the 2023's semestral project was 27.62 points (SD=10.925). This suggests that the SCRUM method used in 2023's semestral project led to better results in students' achieved scores.

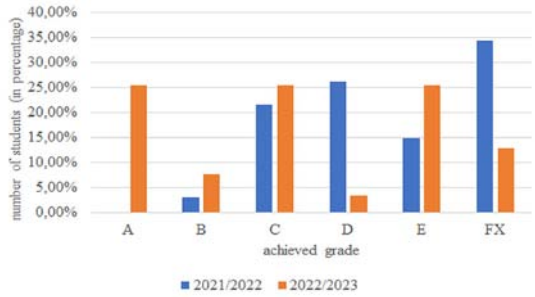
To investigate the statistical significance of these increases in the scores, it was necessary to conduct proper statistical tests. In order to choose the proper test, the normality of distribution was tested by Kolmogorov-Smirnov (0.141, sig.=0.000) and Shapiro-Wilk (0.906, sig.=0.000) tests of normality. Both tests indicated that the scores were not normally distributed. Therefore, a nonparametric Mann-Whitney U test was conducted to identify if the difference in students' mean scores between the SCRUM and non-SCRUM educational approach was statistically significant. Mann-Whitney U test was conducted using IBM SPSS statistics software on adjusted students' scores for semestral projects for both years.

Mann-Whitney U test reported a Z score of -5.133 and a 2-tailed p-value of 0.000 indicating a significant result (at the level of α=0.05). Mann-Whitney U test results indicate that the difference between SCRUM and non-SCRUM educational methods in semestral projects' results is statistically significant. Therefore, it can be concluded that the use of the SCRUM method brought better educational results in this case.

As far as SP is concerned, we were also interested in a possible shift in the quality of the submitted assignments. Based on the comparison of the scores obtained by the students within the individual year groups (Figure 4), we can conclude that after the introduction of teamwork, there was an improvement in the quality of submitted projects. In the academic year 2022/2023, there was an increase in the number of projects of excellent quality (25.42%), an increase in the value of projects in the

upper scale of assessment scores, and a decrease in the number of projects with the lowest quality by 21.65%

Figure 4: Comparison of semestral project ratings in different academic years



Source: Authors.

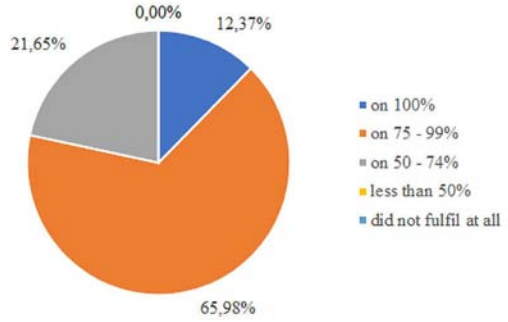
In addition to the quantitative indicators, we were interested in obtaining and evaluating qualitative indicators via a course feedback questionnaire. The questionnaire was extensive, containing 68 questions focusing on different aspects and parts of the course, but due to the focus of this article, in the following, we only present the results related to obtaining students' opinions on areas connected with the use of the SCRUM method in the course. The questionnaire was completed by 97 respondents, i.e. every student who successfully completed the course in the academic year 2022/2023.

Similarly, to the evaluation of the whole course, the questions focused on the evaluation and students' views on SP were divided into categories using the MSLQ method, i.e. we were concerned with mapping students' motivation and learning strategies. Learning strategies cover the fields such as time and study environment, peer learning, and help-seeking. As the semestral project was more complex, we were first interested in whether the students were sufficiently satisfied with the information provided before the actual implementation of the project and whether the given materials prepared them for the solution of the project. The answers show that 91% considered the information and materials provided to be sufficient and 9% did not know how to evaluate the materials, while 69% of the respondents also found the information to be understandable. Our experience shows that regular work on the project is an important factor for successful project processing because due to its complexity, it is challenging if students leave all the work on the project for a short period of time just before the deadline. Therefore, we were also interested in how regularly they worked on the SP.

The answers show that 82% worked regularly, which can be seen in the achieved results, and 7% declared that they did not work on the project regularly, but rather at the end of the deadline. Around 11% of respondents did not want to comment on this question. At the same time, we were interested in what they considered to be the most important obstacle in the development of the project. The majority of students identified team harmonization as the most important obstacle when working on the project (24.74%). This is because students work on such a project first at the university study, and they do not know each other from other courses where they learn in smaller groups. Therefore, at the beginning, it was really difficult for them to get acquainted with the subject and the objectives of the SP, as well as with their new colleagues, and to get in sync with each other. However, when asked what they learned while working on SP, the most frequent answers were to work in a team (40.20%), to apply the knowledge gained to a practical problem (36.08%), to meet deadlines (18.56%), to work in an environment simulating a company (16.49%).

Motivation covers fields such as external and internal motivation, orientation to the course objectives, task value, and control of learning beliefs. Every conscious activity of man is performed with some expectation. Therefore, we were interested in whether our graduates also had fulfilled expectations after completing the course. The questionnaire shows that the course fulfilled students' expectations (Figure 5) on varying levels. Satisfaction with the subject was the highest at 75-99%.

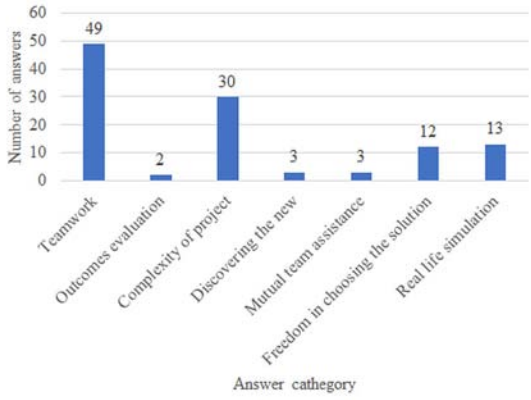
Figure 5: Respondent's answers to the question "How did the course meet your expectations?"



Source: Authors.

Another good signal is the fact that 81% of the students consider the completion of the SP as a benefit and 92% of the students found the SCRUM-based SP interesting. To find out what the students enjoyed most during the project, we asked them an open question. We then categorized the individual answers based on the content of the answer and the frequency of occurrence of keywords from that category. Based on the achieved answers, we have obtained the following categories: working on time (i.e. regular meetings with classmates, forming team habits, the need for cooperation, etc.); the possibility of evaluating and presenting the created in front of an audience of other students; the complexity of the task (which represented the possibility of creating specific performances, so that everyone in the team was able to find an area within the subject that could be applied here and was closest to him; discovering the new (for example, working in an application that was not introduced during the course - the need to learn something new independently); mutual team members assistance/help; freedom in choosing the solution (as only acceptance criteria were given, but not the exact description of the outputs - strengthening creative thinking); real-life simulation (i.e. simulation of the solution of the project in the company). The obtained numbers are presented in Figure 6.

Figure 6: Students' most interesting part of SP solution (in number of answers)



Source: Authors.

Some responses included answers that could be assigned to more than one described category. These responses were assigned to every of the possible categories defined by us. As can be seen from the graph, the most frequently mentioned answers include categories such as teamwork and complexity of the project, which could lead to confirmation of our assumption. The complexity of the project allowed students to choose the area where they felt most confident and could express their talents.

The teamwork helped them to share their knowledge, especially in the process when they needed to approve the performance as a team. And this was only possible after explaining the partial solution to the other colleagues in the team.

During the project management, based on the interim control, we were able to identify two groups of teams. The first type (approximately presented by a quarter of the teams), which, despite the instructions, introduction to the SCRUM issue, continued to apply the Waterfall method instead of SCRUM in the project management, and these groups subsequently had difficulties reacting to the proposed changes, because it would mean in some cases a significant reorganization in a team, time schedule or similar. This type of team didn't use the Trello application for project management, but other applications e.g. MIRO, MS Teams, and MS Excel supplemented with Messenger for the exchange of reports within the team. The second type of team studied and tried to practically implement the SCRUM approach during the project solution and intensively cooperated with the product owner, which transferred to a higher quality of the team outcomes. These teams also actively used the recommended application, which allowed them to monitor changes and solve problems in a short time.

In terms of building teamwork skills, we have observed different situations and approaches of team members to solving project tasks. Some teams had to cope with the loss of a member. In several cases, a team member suddenly stopped cooperating for some reason (health problems, lack of interest, a part-time job and lack of time to participate in the project, quitting the study, etc.), but on the contrary, in some teams, the members continued to work on the final products even though it was clear to them that they would not finish the course this semester (e.g. they did not pass credit exam, final exam, etc.). In the future, it would probably be a better way to explain in more detail the benefits of the SCRUM method and to give more support to the teams (e.g. teachers could more often enter into the management of the project solution, emphasize the need for shorter sprints, etc.).

In addition to the identification of the types of teams, we also discovered several shortcomings related to either the assignment of the project itself or the description of our requirements and their relevance, especially from the point of view of solving projects using the SCRUM method. These shortcomings will need to be addressed in more detail in the next academic years. Among the manifestations of these shortcomings, we can include shortcomings in the students' performances, such as e.g. insufficient elaboration of the result reports, insufficient or completely missing analysis of the current state of the company, and clear identification of the innovation they would like to implement, non-delivery of some performances because they represented only an intermediate step between specific performances of user stories. Thus, we did not assign them any score, which the students automatically considered irrelevant to pass. Finally, we could also identify incorrectly prepared retrospectives of SCRUM teams which resulted in difficult identification of problems in time when solving the project.

6 Discussions and research limitations

The main objective of our research was to find out whether the use of PBL with SCRUM has any impact on the results obtained by students. As we described above, in the academic year 2022/2023, the number of successful students increased by 15.02% in the case of passing the credit exam and by 16.73% in the case of graduating subject Informatics II. Surprisingly, the average number of achieved points within the credit exam decreased slightly when comparing it to the year 2021/2022. From our point of view, this situation is the result of collaboration and more involvement of students in teamwork on the project, where even students who do not have sufficient technical skills had to work on the development of the project solution and thus use their knowledge from face-to-face classes. On the other hand, in the overall evaluation, the students were more successful, which is again a manifestation of cooperation and teamwork. Teamwork is a significant factor that was also reflected in the quality of the SPs delivered (Figure 4). The teamwork was initially difficult for the students, but the results obtained in the PBL were good with few exceptions. As many as 81% of the students considered working on the SP as a benefit.

One of the problems of PBL is the regular work and the constant involvement of students in the project. Through discussions with students and interim checks during the semesters, we found that in case of problems, students helped and assisted each other when there were any irregularities, which is in accord with the results of multiple other studies (e.g. Crowder & Zauner, 2013; Zhou 2012). They also identified the organization of time as one of the crucial problems. Our results suggest the assumption that by the introduction of SCRUM, it is possible to reduce the level of these impacts. As many as 82% of the students confirmed that it was necessary to work on the project transversally if they wanted to achieve the set acceptance criteria in the individual user stories. At the same time, the students also confirmed the improvement of their soft skills, especially in the area of teamwork, application of acquired knowledge in solving practical problems, and the ability to meet deadlines, with 92% of them describing SCRUM-based SP as interesting. This result can be considered excellent, especially when we worked with the SCRUM method for the first time.

Our achieved results correspond with research results presented by Mahnic and Drnovšček (2005), where authors, based on their experience with the implementation of the SCRUM method in Computer Science Education, found that the use of SCRUM in education increased students' motivation and sense of responsibility for the success of their project. In addition, students had the opportunity to develop their talents within the team, as it was not defined who had what role to play, but the team managed itself based on the knowledge of their personal preferences and skills. Mahnic and Drnovšček (2005) also point to the fact that working on the project allowed students to grow not only as team members but also as individuals.

Like the findings presented by Milašinović and Fertalj (2018), we also gained several important insights in the framework of the evaluation of the course implementation: there is no unique view on how long it would be, how would it be organized and who and how will define for example SCRUM team members. Based on the questionnaire answers and our notes made during the SP presentations, 11 teams confirmed that the team members changed their positions during the project, as well as the defined responsibilities for individual tasks within the team, and the requirements for the content of the product created.

The introduction of SCRUM and PBL means that the teacher needs extra time and work to prepare the whole process, while a common problem is the preparation of special materials that allow students to understand the methods and at the same time point out what is essential for the project. It is therefore essential that the instructions produced and subsequently published contain precise characteristics and performances so that teachers can comment on them unambiguously during the evaluation (Markula & Aksela, 2022). This requires a new student performance evaluation approach. As stated, by Zhang & Ma (2023) and Guo et al. (2020), despite the high number of published studies in the field of PBL implementation, it is not always possible to evaluate and compare the performances because many publications do not provide enough statistical information to compare the published works. It would be useful to educate teachers more in this area and to create different manuals and possibly uniform documents where every teacher could find indicators that need to be taken into account when introducing PBL into education so that it would then be possible to realistically assess the impact of the introduction of PBL into the environment of a given educational institution or a specific subject. Our ambition, taking into consideration our personal experience and other researchers' outcomes, is to design a framework for the implementation of PBL at our faculty that will provide a list of important recommendations for the PBL implementation process and a list of indicators, and the possibilities of obtaining them, to be able to subsequently

evaluate the contribution of this method in education from different aspects like cognitive outcomes (knowledge, cognitive strategies), affective outcomes (perception of the benefits of PBL, perception of the experience of PBL), behavioral outcomes (skills, engagement, motivation) and artifact performance, similarly to Guo et al. (2020).

7 Conclusions

The main role of higher education is to provide innovative education for students who will enter the labor market in the future, and it is important to focus not only on the acquisition of hard skills but also to enable them to grow in their competitiveness (Crosling, Nair and Vaithilingam, 2015) and supporting their autonomy during learning tasks (Martín, Potočnik, & Fras, 2017). Project-based learning can meet such needs. PBL emphasizes knowledge construction and innovation competence because it allows students to test and achieve their ideas in the way they want (Krajcik & Shin, 2014).

Different changes were made in the Informatics II course, driven by the aim of encouraging student motivation, enhancing their learning activity, and improving their results. As our research results suggest, PBL is suitable to achieve this, and the results from the surveys conducted over two years and other collected data indicate that students achieved better results not only in PBL-based semestral projects but the introduction of PBL into course finally enriched also results of course as whole. At the same time, PBL affected not just learning outcomes, but it improves their confidence in their technical skills, but also transversal skills increasingly in demand in the business world, that classical methods do not develop (Saunders-Smits and de Graaff, 2003).

As presented World Economic Forum (2022), investing in collaborative learning should translate into an increase in the productivity of the world, which is a fraction of the additional $2.54 trillion in increased productivity to the global economy. Agile management methods, based on the teamwork principle, also have a demonstrable positive impact on business performance (Langholf, & Wilkens, 2021), and more and more organizations are planning to implement it soon, up to 70% of enterprises in the next three years (Weichbroth, 2022). As is presented in Brower (2022) the agility and implementation of agile approaches have a growing tendency and represent one of the tools of successful innovative project management. Around 65% of surveyed organizations (McKinsey, 2021) confirmed the significant impact on their financial performance after the transformation to an agile-based organization. The most frequently used method is SCRUM, which is used by 78% of users (enterprises) who have already implemented agile approaches. As mentioned above, the SCRUM method was originally developed for the innovation environment of software development, but it is gradually finding its place in project management in other areas of practical life. A similar situation is also in the field of education, where this method is implemented mainly in the framework of Computer Science Education (Sutherland, 2004). Our paper was intended to point out the possibilities of using this method in economics education, although in this case, it was also a technical field - business informatics. It is important that graduates of higher education gain as much practical experience as possible from the approaches taught in practice during their studies so that after graduation they can participate more effectively in the development of the economy and society as soon as possible.

As Schwaber (2004) states, frequent inspection throughout the life of the project is important for the successful implementation of the SCRUM method. This fact was confirmed by our results: teams that communicated more intensively with teachers as product owners achieved better results in the final SP evaluation than teams that relied only on their interpretation of the project assignment. In these teams, communication was ultimately difficult, and producing results was more complicated. Students had to laboriously modify their performances several times, change the responsibility for a given performance in time, etc. In these teams, it was often a problem that the SCRUM master and his team did not develop the so-called Sprint backlogs, which complicated the teachers' interim control. In the framework of the Trello application, it was possible to follow at least the discussion of the individual expected performances and the gradual addition of these performances.

The success of the SCRUM method is hidden in the loss of the classical approach to project management, such as the Waterfall method, and the enhancement of collaboration in time and participation of team members not only in the solution and development of outputs but also in its self-management. The SCRUM Master is not a team manager in the true sense of the word, but rather a facilitator and servant leader. As the literature states (Cedere et al., 2020; Seemiller & Grace, 2017) the younger generation wants to participate in the solution of projects but at the same time, they are interested in actively participating in management and decision-making so that they can give their work a deeper meaning. It is therefore also our task to innovate education in this sense. That is why we have decided to "revive" the proven method of project-oriented education, where students acquire real practical skills and implement the acquired knowledge in solving a practical problem, or to make it even more accessible to students by implementing the SCRUM method. The use of this method motivates students to discover new possibilities and to look for innovative solutions. This ultimately enhances students' participation in the education process, which was confirmed by our experiment in the framework of the implementation of the Informatics II course.

Despite the published positive results of using SCRUM in educational settings and its implementation in project-based learning (Fernandes et al., 2021; Cubric, 2013; Dinis-Carvalho, 2019), we have discovered several shortcomings that need to be researched in more detail in the future and solutions for improvement need to be proposed.

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Primary Paper Section: A

Secondary Paper Section: AM