8th International Scientific Conference
Technics and Informatics in Education
Faculty of Technical Sciences, Čačak, Serbia, 18-20th September 2020

Session 2: *IT Education and Practice*

Professional paper
UDC: 37.018.43

On-Line Programming Course Model for Students in IT

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Abstract: *There is a lack of connection between the industry and educational institutions. Students which graduated from colleges are looking for employment and facing difficulties adapting to the current job market, the requirements and expectations, with their minimal amount of real work knowledge. The main goal of this paper is to provide a model for creating a comprehensive developer course aligned with the current industry standards in IT.*

Keywords: *IT; undergraduate; backend; e-learning; teamwork.*

1. INTRODUCTION

Students represent the future of each country and adequate investment in education brings long-term results that distinguish between developed and underdeveloped countries. The education system has changed over the years trying to keep pace with the development of the industry and its needs. Systems that recognize in time the essential need for closer cooperation between education and industry have a real opportunity to become leaders in technological growth.

However, there is always a gap between the needs of industry and what educational institutions provide. The goal for students is to get a degree as soon as possible, and it is in the interest of employers to get employees who can immediately get involved in the work process.

One of the most common problems in education is bridging the gap between educational institutions and the industry [1, 2, 3, 4]. This gap was wider in the past, but with current advancements in education and partnering with various industry partners has narrowed the gap considerably. However, this has not closed the gap completely. With companies constantly moving forward in order to gain the edge over their competition, it poses a new challenge of constantly being up to date on the latest trends in IT. In most cases, students must spend at least 6 months in training, at companies, before they can start working on projects. One of the more common problems are the tools companies use in their development, often times these tools are unknown to students, and, unfortunately for them, have a steep learning curve.

This course model has the goal of improving existing skills previously gained in higher education based on the real-world needs of companies. Also, this model combines these skills in order to create a deeper understanding of how they are all linked together. Common programming and design concepts can be applied to all programming languages. The course is expected to prepare students for the challenges they face in the business environment, with an emphasis on the most common requirements in such an environment, without wasting time on classic programming lessons that are present in most schools or colleges today, as one assumes that this knowledge has been adopted, and this is an upgrade and preparation for actual work. The demands of employers are such that they expect employees to solve a given problem as soon as possible, regardless of the level of complexity, and most students cannot adequately respond to such demands of employers and the market. The course should provide the knowledge and experience for this type of requirement.

The concept of the course presented in the paper participated in the Public Competition of the Ministry of Education, Science and Technological Development for application and participation in projects financed within the program activity "Development of Higher Education". Based on the preliminary ranking list of the Ministry, the project "Development of mobile applications" won the maximum number of points and will be financed by the Ministry during the school year 2020-2021. The project will be implemented at the Academy of Vocational Studies in Western Serbia, Užice department, during the winter semester of the school year 2020-2021.

The subject of the public competition is the financing by the Ministry of Education, Science and Technological Development of projects to support higher education institutions in the development of new and innovation of existing subjects within accredited study programs, which should contribute to the Ministry's program goals:

1. Improve the competencies of teachers and associates for teaching;
2. Innovate existing study programs that follow the needs of the labor market;
3. Improve the quality of the educational process by creating better conditions for the implementation of teaching and learning of students;
4. Develop the entrepreneurial skills of students and improve the cooperation of the higher education institution with the economy and other interested actors in the local community;
5. Increase the use of information technology in teaching and learning process.

2. E-LEARNING CONCEPTS

The concept of e-learning is not new and over the years it has successfully adapted to new trends and developments in IT, which are a necessary component in the implementation of this concept. Keeping in mind that e-learning has expanded from classic computers to many other devices, such as tablets, smartphones etc. Most, if not all, e-learning systems of today are platform independent, usually web-based services, that will run on anything that adheres to web standards. Some of the key advantages of e-learning are: mobility, the ability to access learning content from anywhere, higher flexibility, increased study efficiency, etc. [5]. There are some drawbacks which include the inability to convert all classic courses to online courses, it requires extra motivation and good time management in order to avoid work piling up, there is also the question of cheating, however, that is a problem present in classrooms as well [6, 7].

E-learning systems typically consist of three key elements: LMS (Learning Management System), Content and Collaboration [14]. It is necessary for all components to function for the purpose of the system. There are various LMS variants, such as Moodle, ATutor, Chamilo, Blackboard and others, with different options and tailored to different needs. However, all of these systems have one common flaw – test validity. This raises the question of how to provide relevant knowledge to students that they will recognize as relevant, which, in turn, will provide employers with quality employees. This would ensure that students have a smooth transition to the work force, employer satisfaction and overall a win-win situation for everyone.

Reflecting on this problem, it is very difficult to prevent students from cheating, in most cases, students get very creative when it comes to it. The idea is to offer them a solution in which they get the conditions to work in real-world conditions, with real-life examples of practice. Students do not like long internships or probationary work, with very little or no pay at all and employers are not happy with knowledge students possess. In a way, students can gain knowledge that will help them get involved in the work process very quickly and will free employers from waiting for new employees to start delivering results.

In terms of virtual internships, there have been several successful projects that tackled these problems, such as the ProVip and VIVET projects [8, 9]. They are a good example that content matters and that students will show interest for innovative technologies and approaches if they find value in them. These two projects partially address the issue of transitioning to the works force and the challenges that come with it. Younger generations have grown up using the Internet and online communication is completely natural for them.

Learning teamwork skills is crucial and previously has been documented using different frameworks that are based on problem based learning and collaborative approaches [10, 11, 12]. Having in mind the goal and purpose of this course, it is evident that the shortcomings of the e-learning concept itself will not significantly affect the effectiveness of the course itself, since the target group has the appropriate level of knowledge necessary to apply all the necessary elements. The students will be focused on solving specific problems, which is why the concept of the course does not rely on traditional and widespread dissemination methods, but rather on creating, in the future, a database of ready-made examples based on realistic requirements of employers. This will teach students to solve specific problems in as little time as possible and with limited support, just as it would be in a real environment. During Agile software development, teamwork and creative thinking is beneficial to everyone in the team. If workers see that their ideas are encouraged and accepted, they will be more likely to be creative, leading to potential innovation in the workplace. The creation of a collaborative work environment fosters the communication between employees and reward those that work together to solve problems [13].

In order to help narrow this gap the results of the EDUCAUSE Center for Applied Research (ECAR) from 2004 to the present were observed. This research looked at the interests of IT students, as well as their satisfaction with their studies. The research included different demographic groups, the way of using new technologies as well as the

most common use of computers, both for the needs of studies and in everyday life [14-22].

3. RESEARCH PROBLEM AND RESEARCH SUBJECT

The problem of the research is finding the most suitable way to prepare students for the fastest possible adjustment to real working conditions. Employers in the current market conditions are not ready to waste money and time while students adjust to solving problems that are part of the everyday work environment. On the other hand, educational institutions often work according to programs that are not in line with the needs of employers.

The subject of the research is to define such a model of learning that will enable students to solve real problems that are present on the market during their studies, and for such a model to be harmonized with national education strategies as well as with syllabi of different subjects.

One possible way to solve this problem is to work according to the CDIO model. The CDIO INITATIVE is an innovative educational framework for producing the next generation of engineers. The framework provides students with an education stressing engineering fundamental set in the context of Conceiving – Designing – Implementing – Operating (CDIO) real-world systems and products. Throughout the world, CDIO Initiative collaborators have adopted CDIO as the framework of their curricular planning and outcome-based assessment [23, 24].

ECAR conducted the survey on a sample of more than 64,000 students at 130 US and international institutions and it is one of the most representative and longest-running surveys on the experiences, behaviors and preferences of IT students. The research took into account demographic characteristics, age, gender, technical equipment, the way of accessing the Internet, preferences on the Internet, technical knowledge the way of using the device, experience with LMS, etc. [23].

Based on the ECAR research, students have appropriate devices and spend enough time at home doing research and homework to make this kind of model possible [23]. However, bear in mind, these results vary from country to country, especially results such as internet access and device availability.

All these characteristics represent potential variables that can be taken into account when planning and implementing questionnaires for IT students. In addition, it is necessary to carefully plan the sample size in order to obtain relevant results, but this is in the plan for some further work on this topic because it requires precise determination of research techniques, instruments and activities.

In order to assess the opinion of students and college graduates that are working in the IT industry. The questionnaire had one closed question and two open ones.

For the purposes of the research, the sample method was applied and it enables the relevant statistical information on the mass phenomenon to be determined on the basis of a small sample. The reliability problems of the sample method are reduced by determining the sample size and representativeness of selected units [25].

The research was conducted on a relatively small number of respondents, but it provided guidelines in which direction the course should be further developed and how to eliminate possible disadvantages of this concept.

The questionnaire was answered by 37 individuals out of which 16 were college graduates that are working in the IT industry and 21 were students.

The questionnaire consisted of the following questions:

1. I think that it is a good idea to assign small projects (problem-based learning) so that students may acquire and expand their programming knowledge.
2. What do you consider good about the way programming is currently taught?
3. What would you change in current programming classes?

Analysing the questionnaire results, on the first question regarding the introduction of problem-based learning through small projects, it can be concluded that both students and graduates think that it is a good idea, with graduates strongly agreeing with the statement – 75% answered with Yes (Figure 1.).

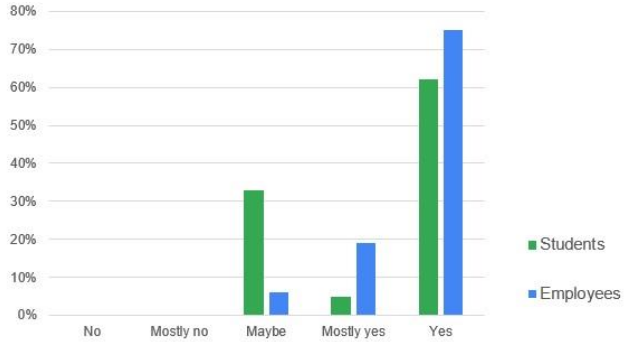

Figure 1. *Students and Employees opinion on introducing problem-based learning through small projects*

When asked the second question, what they consider good about the way programming is currently taught, both students and graduates answered similarly with the most common answers being:

- Working with professors and assistants;
- Gradual learning through teaching units;
- Small groups of students;

- The desire and commitment of the professors to impart knowledge;
- Introduction to programming is based on C language which is crucial to having a deeper understanding of how things work in the background.

When asked what they would change in current programming classes, students answered with:

- Pen and paper programming;
- A wider choice of programming languages;
- More team projects;
- A higher number of homework assignments

However, graduates had a lot to share, to summarize:

- Use industry standard software;
- Emphasis on the development of software solutions;
- Problem solving based on real world examples;
- Follow the latest trends in software development;
- Assistants should follow team-based projects and intervene when necessary;
- Do not repeat projects year over year;
- More attention to code formatting;
- Pay more attention to tools such as Git, Jira and documentation writing;
- When projects are assigned, teams should have a clear picture which way the project is heading at the beginning of the project, cooperation with other teams should be incorporated and projects should be split in parts and assigned to different teams.

The graduates had a lot more to share due to their industry experience. Their opinions are based on the difficulties they faced when transitioning from an educational institution to the industry and may be used to fill the gaps in current software engineering and programming courses. The course workflow described in this paper aims to fill those gaps and encourage teamwork-based projects.

4. THE COURSE CONCEPT

Based on the CDIO project, ProVip, VIVET and other similar projects, the results and lessons learned, a course concept has been created describing the course prerequisites and workflow.

4.1. Course Prerequisites

This course is intended for students that have already acquired object-oriented programming basics and have some experience writing code. It would be desirable if students are aware of networking concepts and have basic database knowledge, as the course is centred around working on existing projects that already incorporate these technologies.

This is why this course concept is intended for High School and College undergraduates who already completed basic programming courses, as this course require knowledge from several key areas. The tools used during the development cycle would be defined by current industry standards. Students would rely on IntelliJ IDEA, Docker, Visual Studio Code, Xcode, GitLab, Jira, Amazon Web Services, etc., as these are the tools that the industry is using to develop their software. It is important to note that these tools have student and/or free versions available. The transition from faculty to IT companies would be smoother as the they would be familiar with industry standards in terms of development tools.

Remote work, working individually, as well as working in teams will be encouraged, so students would need to have their personal laptops, faculty provided laptops or personal computer rooms available to them, as these activities will be completed outside of classrooms. This should not be a problem, as seen from the ECAR research data. Monitoring of the workflow would be achieved using issue tracking and collaboration tools, git repositories, lifecycle management and continuous integration and development tools.

4.2. Course Workflow

A course with this approach requires more time to track, not to mention a lot more time to implement properly, however, it represents a real work place environment. The projects would be divided into stories, tasks and subtasks which students would complete to earn story points. The amount of story points given depends on the difficulty of the task/subtask. Some projects may be frontend-design focused, while others may be backend focused which would be merged during the final phases of the projects, in order to create a sophisticated software solution from multiple small-scale projects which students, with their limited experience, could manage.

The course would begin with an introduction to the software students will be using during their course, registration and a demonstration of the tools and how they work, with a special focus on issue tacking, code repositories, tickets and other management and synchronization tools that will be used during the course. Students would be encouraged to hold stand up or Kanban meetings at agreed upon times and frequencies.

Once this phase is complete, the professor would switch roles. Issue tracking is monitored by the professor with intervention during key phases of the project. The professor would take on a supportive role, intervening only when deemed necessary. This role could also be described as a project manager role.

The previously mentioned software, with tickets and story points would encourage students to work both independently and as a team. Students would

complete tasks and earn points, which is great to showcase who did what and to evade some students working more, while others slack off. Issue tracking tools would serve as a source of truth. Git repositories provide version-control and encourage work coordination between students, especially when merging code. When a merge request is created, other students review the code submitted. This creates team responsibility for the code, the student who submitted the code shares this responsibility with their teammates who review it for faults, bugs, formatting issues and so on. This way, code quality is a team responsibility and it allows students to learn from each other as they make their way to the final software product.

The professor would keep his supportive/management role during the entire development process, only breaking from it once the software development phase is over and the evaluation phase begins.

During the evaluation phase the professor take on the role of the evaluator – teamwork, application code and deployment would be reviewed. Students would also deliver a lesson learned report for evaluation as it is one the most important documents of a project. The professor would also review this report and, based on all of the evidence provided from tools and reports, decides on the final grade.

A general flow of the course is shown on Figure 2.

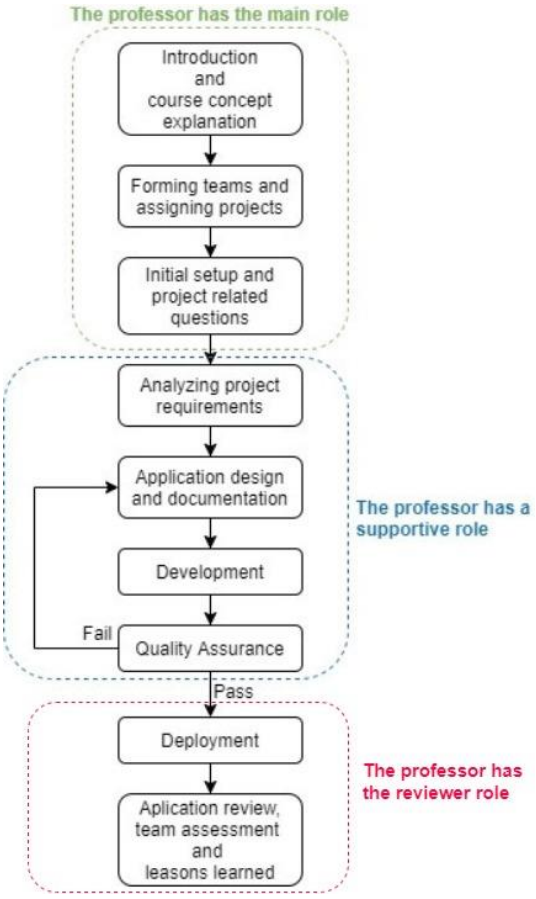

Figure 2. *Course flow*

The Ministry will evaluate students who are taking the course, which has been introduced or innovated. The project manager is obliged to submit to the Ministry the e-mail addresses of students that will be used for online evaluation within 15 days from the beginning of classes.

The results of the Ministry's evaluation and the independent evaluation will be analyzed in detail and we expect them to provide clear guidelines on how to develop these types of courses.

5. CONCLUSION

What can be concluded from ECAR and similar research? First of all, it is necessary to be well informed about study programs, accreditation documents and standards related to this area. It is necessary to precisely define the goals and steps in their realization. The questionnaire that should help achieve the goals needs to be defined in accordance with the conditions that apply in the educational institutions and industry.

Employers have a clear need for staff who are capable of solving real world problems as soon as possible. This type of course should prepare students for real world challenges in everyday work tasks. The biggest challenge is how to motivate students, as well as how to choose the most optimal course flow, with examples that will be closest to real situations.

Based on the research conducted in this paper, it can be concluded that students are open to problem-based learning and more practical classes using small project and find it useful for their future careers. This aligns with the results gathered from the IT employees, with the employees being in even stronger agreement on problem-based learning and more practical programming. Similar results have been gathered during the ECAR, ProVip and Vivet projects.

The research shows how to reach a compromise for both parties – how to create an appropriate programming course that will help students acquire the necessary knowledge and skill, while enabling employers to easily gain quality employees. In that sense, this would be a win-win situation.

During the implementation of the project, an evaluation is planned by the Ministry, as well as by the project manager and the author of the paper, which should provide guidelines on how to eliminate shortcomings in the very concept of the course.

The project manager is obliged to submit to the Ministry a final report on the implementation of the project, as well as evidence of the realized financing of the project, no later than 30 days after the end of the semester in which the project is implemented.

This research suggests in which direction programming courses should improve in order to

achieve the desired goal and the current shortcomings in teaching programming. It is evident that it is necessary to expand the research to a larger number of respondents, as well as that the concept and flow of the course should be well developed. However, an implementation of this model, further testing and result analysis is necessary.

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