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Measuring Team Member Performance in Project Based Learning

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Abstract

In this paper the authors present how they implemented Project-Based Learning (PBL) at Subotica Tech - College of Applied Science and how they measure the individuals' performance in team work. Given that PBL takes place in group work, the students' marks were formed on a group level depending on how well the project was realized. Experience has shown that the "one mark fits all" approach may not be adequate for the majority of the students, because they strive for feedback so as to help them grow and improve. This motivated the authors to study the functioning of the group and individuals, and identify suitable metrics for measuring performance in the group at the level of the individual. Data collection about the topic was conducted via questionnaire. By analyzing the feedback from students and the results of developing the applications, it can be stated that the PBL approach in teamwork is accepted by the students. Authors suggest metrics for measuring individuals performance, but also state that three years after the implementation of this approach there is still no ideal way to be objective towards every team member individually.

*Keywords:*project based learning; measuring team performance; agile development;

1. Introduction

Modern industrial societies generate a huge need for well-educated engineers. The need is especially great for those who completed their computer science studies. Key goals for higher education institutions include the need to educate, to teach, to transfer the up-to-date knowledge materials and techniques. Based on the requirements formulated by the industry (Privredna komora, 2017), Subotica Tech is also trying to adapt the curriculum and the students' competence to the needs of industry (Gőgh- Kővári, 2018).

The growing need, or seen from another aspect, the considerable lack of IT engineers can be explained by the following facts:

- Education is always one step behind in teaching or applying the new, current, or even the latest technologies. ICT is a very dynamic field which produces new technologies at a greater and faster rate than other fields. It often happens that while the curriculum is under

development, the described technology changes to such an extent that by the end, when the curriculum is finished, it is not current any longer.

- Education produces different results in terms of competencies and acquired skills. There are numerous reasons for that, including the different teaching methods or equipment used in the learning process, or the difference in the students' level of motivation. Another problem must be mentioned, causing lower knowledge and skill transfer: the motivation of the educators. Their knowledge, skills and motivation are crucial for a successful teaching output.
- Students learn fundamental engineering knowledge, but they do not know how to implement it in real situations.
- Most of the curricula teach schemata for solving problems. The students' creativity is suppressed.
- Besides fundamental engineering skills, there is also a growing need for communication skills and the ability to work in groups.

2. Project vs. problem based learning

In this section the authors explain the main characteristics of project based learning. First, it must be described what the difference is between this approach and problem based learning. There are certain similarities between these two, though they are not the same. The main similarities are (Savery- Duffy, 1995; Loyens- Kirschner- Pass 2001):

- Focus is on an open-ended question or task.
- To provide authentic applications of content and skill. Emphasize student independence and inquiry.
- They are longer and more multifaceted than traditional lessons or assignments.
- Build skills for 21st century success

The main differences can be described as (Perrenet-Bouhuijs-Smits, 2000):

Table 1. Differences between PBLs

Project Based Learning	Problem Based Learning
Often multi-subject	More often single-subject, but can be multi-subject
May be lengthy (weeks or months)	Tend to be shorter, though can be lengthy
Follows general, variously-named steps	Classically follows specific, traditionally prescribed steps
Includes the creation of a product or performance	The "product" may be tangible or a proposed solution, expressed in writing or in a presentation
May use scenarios but often involves real-world, fully authentic tasks and settings	Often uses case studies or fictitious scenarios as "ill-structured problems"
It is easy to integrate it into the content of the course, while at a problem-solving course, the content is more difficult to define	Problem-solving is hard to integrate into curriculum
Working on a project means managing deadlines and resources	Managing resources is not so specific
The project mainly requires the use of already existing knowledge	Problem-solving emphasizes the acquisition of new knowledge.

Apart from the fact that the terms Project and Problem based learning are very often intertwined, the previously described differences highlight that these two approaches have

different terms of implementation. Nonetheless, both learning approaches are methods which can supplement the classical teaching system.

On the web page of the "Problem Based Learning Initiative" (PBL Initiation, 2017) there are interesting cases of applying PBL in medicine. Those cases and from other researches (Werty-Ben-Delsarte, 2005; Mills- Treagust, 2004; Gagnon- Tsushima- Lehner, 2015) describe important characteristics of PBL. Some of the prerequisites of using PBL efficiently are:

- Students must feel responsibility for their education. Since this is the approach in which the student is in the centre, it is expected that the motivation for acquiring new knowledge increases if the student feels responsible for troubleshooting, project development and management of these processes.
- Tasks that can solve these approaches must be arranged to allow a variety of ways to reach a solution. What is called in everyday life a "problem", has complex character, otherwise it would not be called a problem. One of the most important skills that students can acquire through the PBL approach is the problem recognition and defining those parameters that could lead to solutions. If the task is not complex enough, and the way to the solution is relatively well defined, then the students are less motivated to create their own specific solution.
- In the process of solving the problem it is preferred to apply the knowledge from various disciplines, or scientific fields. Different perspectives lead to a deeper understanding of the problem and the creation of better solutions.

3. Motivation

Three years ago, the authors introduced Project Based Learning at Subotica Tech. The new approach was implemented in a course about development Android applications. The reasons for using PBL are:

- Mobile phone applications are solutions for real world problems.
- The applications are complex in nature.
- There are many solutions to the problem.
- Development requires knowledge from many fields of information and communication technologies.

While the previous list described advantages of using PBL from the students' point of view, here follows an account of how the teacher can also benefit from it.

From the teacher's perspective, presenting the capabilities of Android OS and the implementation of that knowledge in the app development requires far more time than is available in the semester.

Even if the teacher reduces the material about the Android operating system, the problem still remains, because it is possible to develop a wide range of different types of applications. For example, the teacher can focus on developing games, or geolocation apps, or some entertainment app (listening music, chat etc.) or even financial apps. Different types of applications use different features of Android operating system. One semester is sufficient for a deeper

understanding and acquiring skills to develop one type of application. Since this is a complex area, the question arises as to whether a teacher has to decide what kind of applications the students need to learn to develop?

The opportunity for students to choose which type of app they want to develop, means additional engagement and learning for them. The motivation for these additional activities can be easily achieved because they will develop whichever type of app they prefer, the one that they prefer the most.

The teacher's role in the PBL approach is changed. The teacher takes on the role of a mentor or a coach. He teaches only those part of curricula which are needed to start the development. The rest of the required knowledge necessary for the project is then learnt by students.

Transfer of responsibility for learning is useful for students as well as also for the teacher. From the perspective of the teacher, this means that the pressure of constantly monitoring the changes in the IT technologies is reduced. Also it reduces the collision with the competencies that students can have in the given field.

Students' competence in specific IT area may be larger than the teacher's, because students can spend much more time studying the given technology which they are interested in. Less confidence due to the lack of competence, can lead to a lower quality of education.

4. Implementation of P(roject)BL

The students' work load in the college course in which the students learn the technologies related to the Android mobile applications is:

- Learning the theory needed to start developing mobile applications.
- Parallel to the previous theory, they learn agile project management methodology.
- After completing the theory, they start with the developing phase.

During the semester the application development is managed using the Scrum methodology (or framework). Scrum is an iterative and incremental agile software development framework for managing product development. It defines "a flexible, holistic product development strategy where a development team works as a unit to reach a common goal", challenges assumptions of the "traditional, sequential approach" to product development, and enables teams to self-organize by encouraging physical co-location or close online collaboration of all team members, as well as daily face-to-face communication among all team members and disciplines involved (Gagnon-Tsushima- Lehner, 2015).

Implementing Scrum in education needs to be done in a different way than in the industry, because the participants are students with little experience in developing software, and there is also a difference in rewards or penalty methods. The other aspects of Scrum were implemented

as if it was a real software developing firm: students used all available tools and events provided by the framework. The only major difference between the suggested and the applied method was the number of student in the group. The suggested size is between 5 and 9 people, but in the college course the authors worked with smaller groups. Depending on the project's complexity, the number of students varied from 4 to 7.

The projects which were developed throughout the semester were client-server type applications. The client application was a mobile app, which does some task locally and communicates with the server. The server manages the communication with the client: it stores the received data, presents some statistics, or sends data from database upon client requests. All the applications have logging and integrated security options.

The entire huge theory of all the technologies required for the developing process cannot be presented in a single semester in one subject. This is why the students have to do additional work by themselves: they become responsible for the project's future, and in order to achieve success, they have to learn some of the material on their own. Additional learning thus entails additional motivation. The Scrum project management framework tries to help in this process with the following features:

Team work. Development is a group task. The group selects a project from the list of problems independently and without external pressure. As mentioned before, in this way, the group will be developing a project that matches the interests of the team members. Each member of the group has the equal rights within the team. Everyone has a responsibility towards the other members and is jointly responsible for the successful implementation of the project. The failure of the project is a failure of the team.

Transparency. During the semester the students are developing the selected project. They specify the project options and priorities in the development process with the teacher. The Scrum tools and events help to track the state of the development, how efficient the group or a given student is. In terms of motivation, it is very important for the group members to have a clear picture of each other's contribution in reaching the common goal. In Scrum, one should not speculate how much the others contribute to the project. There should not be an atmosphere in which an individual thinks he or she is doing more than the others, because it causes a lack of motivation and uncertainty in the project's realization

Motivation. The group is formed by the students. There is no external influence on the structure of the group. Students receive the description of the project in the form of short sentences. Those sentences describe the options that the customer wants to be implemented in the project. A brief description, called a 'story' in Scrum, contains only sparse information about the

required option. By default, the customer knows only what he wants as an option in the application, but does not know which IC technology to use in order to develop that option. Due to the lack of specific orders, there can be several suitable solutions. This is convenient for the students, because they can design their own solution.

There are a number of aspects which have positive impact on students' motivation. For example, the group members determine the task distribution and the resources needed for accomplishing it unanimously. Thus, every member can be allotted a task which is exciting them. The pace of achieving the goal is also determined on a group level. By this, the task distribution and the load are equal in the group.

This approach takes into account the fact that in the group, there are students who have different areas of interest, as well as various skill sets. The heterogeneity of the group is desirable because all members bring their different perspectives to the task, making it therefore easier to understand the problem, and leading to better solutions.

As briefly summarized in the previously sections, the implementation of the PBL approach and Scrum methodology leads the authors to expect that students will be motivated to learn independently and apply what they have learned. This way, they will acquire the ability to identify problems and skills for designing one possible solution. It is worth mentioning that through teamwork, students also practice communication skills. Further, on Sprint Demo events, they have the opportunity to test their skills as presenters of the project. These are skills that are also among the fundamental engineering skills required in the real world.

5. Research results

The main goal of the research was to define the method for objectively marking the students' contribution through project developing. The task of tracking the team members' performance is vital both from the aspect of the teacher monitoring team work progress, as well as another team member, who is, in fact, a student, too. However, quantifying and measuring performance metrics is easier said than done, as the task poses difficulties for both mentioned parties.

This class enables the teacher to measure the performance at team level and at the individual's level. Individual level means how an individual contributes to the team qualitatively and quantitatively. The term 'contribution' covers not only how the individual completed a particular task, but it also relates to the individual's behavior. For example, it refers to how he/she works and communicates with others, to what extent the person participates in team meetings or how pleasant or easy other team members find it to work with the given individual.

Prior to this research, based on the Scrum suggestion, it was decided that only the group as a whole would be taken into account, therefore, the authors formed the students' marks on group level. This means that the project's elaboration at the end of the semester was the key parameter which defined the mark for the students. Due to this team level evaluation, a great number of students showed some dissatisfaction, as there was no differentiation between their own contribution in the group and those students, who they worked significantly less, yet received the same mark as the rest of the group. The talented team members demanded feedback from the teacher, so as to help them grow and improve. This motivated the authors to look into the functioning of the group and individuals, and to identify metrics for measuring performance in the group at individual level.

The study is based on data from questionnaires filled in by the students in the previous three academic years. The number of questions and types of questions in the questionnaire was changing because authors experimented with the applications of the Scrum framework in the learning process. In the current academic year, certain questions were added in order to gain a better insight into developments and the contribution of the individual to the success of the team.

The study involved third-year students of Subotica Tech. The questionnaire varied in length, the shortest questionnaire included 22 questions, while the last in the series was the longest with 39 items. There were MCQ type questions, those with the Likert scale of five degrees and those where students could write answers in textual form.

Many of the questions were related to the Scrum project management system and its options. The answers to these questions are not relevant for this study and therefore they will not be presented within the scope of this paper.

One of the question from the questionnaire was: *How noticeable was the positive contribution of the individual in the group?*

A large number of students answered that they noticed when "certain members" contributed more to the success of the project than others (Fig.1). The answers are probably the result that every individual believe that they were the ones who pushed the group the furthest. The answers also point to underlying problems within the group. These problems have to be solved, because in the long run, they reduce the motivation of team members.

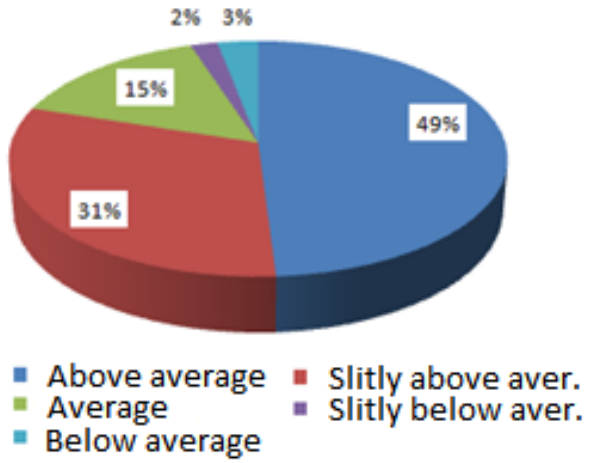

Fig. 1. Contribution of the individual

Another question was formulated with a similar content: How noticeable was the negative contribution of the individual in the group? Through the answers one can gain information about how satisfied the individual was with the quality and quantity of tasks done by other members. The answers, as for the previous question, showed that there was a problem in the system, because, despite the fact that the tasks were assigned under the coordination and with the agreement of all the members, most of the students think that a lot of the members were doing less than the student answering the question. The obtained answers highlight that 41% of the student agree a lot, that there is a member in the group who does not contribute enough. Another 20% of the students agree with the previous opinion, and 31% do not have an opinion. The rest of the students stated that everybody contributed the same.

The previous two questions highlight the problem that the implementation of the project management system in the learning needs some adjustments. The teacher cannot help in those situations, because he does not see the whole picture of all the happenings within the group. Usually the students solved any arising problems themselves. Because the whole team is responsible for the project, those solutions usually mean that somebody in the group takes the task over from the others. This is a typical students' solution, and it is not sustainable in the long run.

The next question relevant for analysis referred to the acceptance of the new methodology in learning: *Estimate how important it is to have someone in the group who will lead the project?*

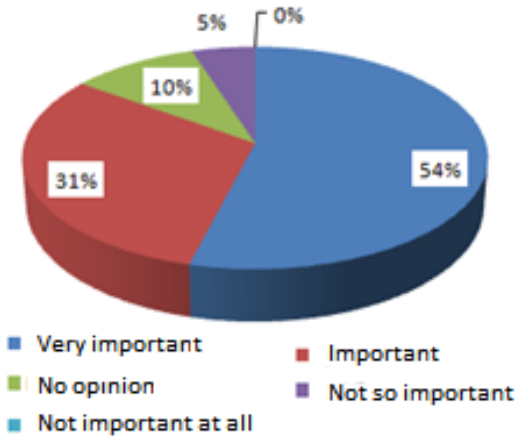

Fig. 2. Importance of having a 'leader' in the group

Although many students liked the idea of working in a group, where there was no hierarchy, the answer to this question shows that students still need someone, a classic 'boss', who will manage the project development (Fig.2)

This can be explained by the fact that the students do not know how to fully adapt to the method in which they themselves are responsible for their own learning. Their educational processes, in primary, secondary and higher education were mainly of the frontal type. The students always had a "person who manages everything". Maybe this is a sign that the PBL approach should be implemented increasingly in primary and secondary schools.

Since this year, the questionnaires also included questions in which the group members could assess the work of their colleagues in the same team. Some of the questions on which each member of the team could grade the others with a score from 1 to 5 are:

- How reliable was he/she in the team meetings?
- Has he/she always accepted the job they were assigned to?
- If someone asked for help, did he/she offer assistance?
- On team meetings, did he/she have constructive suggestions?

Unfortunately, most of these questions did not provide specific information. Generally speaking, students fail to behave not in a manner as expected from future employees. Also the lack of student's previous PBL experience affected their answers. If one of them in the team had greater prior knowledge in a technical field, the others accepted everything that the person proposed. However, this 'easy acceptance of opinion' also meant that knowledge from various disciplines or scientific fields was not applied, and there was a lack of different perspectives, which could perhaps lead to the deeper understanding of the given project problem at hand and the eventual creation of a better solution.

The lack of previous PBL experience and the experience of developing on one's own had another side effect: the students were not able to accurately estimate how complicated their own task was and how much time it would take to complete it. A similar situation arose when a given

team member had to estimate what the workload of another person in the team was. These incorrect estimations led to the previously presented answers, as well as to the lack of motivation and the uncertain future of the project.

To the question about assigned task acceptance, students gave the same grade to everybody in the group. Further research is needed to gain answers as to why someone gave, for example, the mark 2 (a very low mark) for everybody and also for himself. The same questions could be asked in the case when the answer contained the highest mark. Only 5 out of the 60 students' questionnaires contained answer in which the team members were graded with different grades.

The authors also found that there are contradictions between answers to different questions in the questionnaire. The examples include the following:

One the one hand, the answers showed that most of the students were satisfied with the communication within the group. Later, when asked how the group could be more effective, the answer was 'with better communication'. Also, those students, who stated that the communication was good, later when asked about the poor quality of the product (not all groups were successful in their development), answered that 'the communication was bad'. Further contradiction can be found in the questions when the students first gave a bad rating of the teammates' contributions, but afterwards, in another question, they stated that all of the options of the project have been maximally achieved.

There are also thought-provoking answers from students who have come from another study program, and they had obviously less knowledge of the required computer science techniques. They cut down their own scores realistically when asked about their contribution. However, at the same time, when asked what they would change for better efficiency, the answer was: nothing. Also, they stated that the project development process was well done, besides their poor contribution.

6. Conclusion

Agile project management (Scrum) and PBL approach was applied at Subotica Tech since the academic year of 2014/2015. For the past three years more than 170 students participated in the development of more than 50 ICT projects. Based on the answers to the questions from the surveys that the students filled in at the end of the semester, it follows that the Scrum agile management system is accepted by the students:

- 67% of them are satisfied with the possibilities of the Scrum.
- Approximately half of the students were satisfied with the structure of the group, with the work in the team and the way as the development was done.
- 47% of students were satisfied with the fact that they were allotted the task that best suited them.

In addition to the positive experiences, there are also some shortcomings that can be deducted from the questionnaire but also observed through conversation with the students. Differences in motivation for creating application, quality of developed solutions, working habits, level of teamwork skill, learning approach and ultimately individual goals lead to different levels of contribution in project realization.

The project management system contains options for solving these problems, but these solutions also work well in industry where team members have a different status, and there are better methods for influencing someone's motivation.

Applying project management in an educational environment needs specific implementation. The data from the questionnaires was used to gain more specific information about Scrum implementation and happenings within the group.

The problem of the objective evaluation of a student, based on the questionnaire data, has not yet been resolved. The grades that present the acquired knowledge and skills are still formed based on the student's achievement during an oral exam. A paradoxical question arises: should an individual be measured in a team work? Many project management experts unanimously say there is no need for that.

The Scrum spirit means that everyone jumps in to help; ideally, all team members work together on all of the stories. Different skill levels or types contribute to the best of their abilities. To create metrics for individuals, besides being inaccurate, would probably cause competition and division within the team. Individuals should work as a unit, be tracked as a unit, and succeed or fail as a unit (Scrumalliance, 2017).

Many will agree with the previous statements, that there is no need for any metric to track individual performance. But, if there is no measurement of individual performance, therefore it may work negatively for a person who is a high performer. People need to be rewarded by their contribution in the team, otherwise, they will stop working more than what is expected from them.

Another important question arises from applying the Scrum spirit: How can an agile company promote employees? There will be no promotion and career development if nobody pays attention to each team member individually. In order to promote employees one must use any metric or technique that is not only "working time at the company" (Rise, 2017).

There is a suggestion to use in education the following five metrics for measuring team member performance (Scrumalliance, 2017).

Attendance. First and foremost, it is important to look at whether a team member shows up to work or not.

Helpfulness. Helpfulness is important for fostering a culture of teamwork, allowing your team to perform better when tackling difficult tasks together.

Efficiency. Team members need to be able to complete their work on time - Look for missed deadlines, or work that suffers as a result of cramming for deadlines, for clues as to how efficiently a team member is working.

Initiative. It is nice when those you work with ask what is needed and where they can help. It is even nicer when they see a need and take steps to meet it on their own. Initiative is definitely a sign of team satisfaction and engagement.

Quality. Members who care about what they do and are engaged in work will likely perform better, and it is a good idea to recognize the resulting achievements.

Having in mind all the described difficulties of evaluation and performance measuring, the authors are planning to implement a new type of questionnaire next academic year. The aim is for the authors to design the tasks in the project in such a way, that every student is to have a so-called "critical element". This "critical element" is a work assignment or responsibility of such weight and importance that unacceptable performance on the given element would result in a failed overall mark for the project development. In fact, it can be called a 'pass/fail system' based on which the team member can be evaluated. This system, however, is difficult to adjust because each participant must be aware of what is important, what his/her specific task is, at what level "good" performance starts and "bad" performance ends, etc.

Another approach is to form two groups of students: one who does and one who doesn't prefer to work (develop, learn) in the team. This solution is not considered yet for the implementation, because it raises many new questions.

After defining these metrics to measure one's performance, there is still a doubt about implementation, because:

- team members are people and not just resources to be consumed, and
- how can we quantify the performance of the 'rock star' member of the team?

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Short professional biography

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