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# Peer-Assessment for Holistic Student Development (PAHSD): Implementing a Digital Application on a PBL Platform

Simone B. S. Monteiro<sup>1</sup>, Khaled B. Hafaiedh<sup>2</sup>, João M. da Silva<sup>1</sup>, Ana C. F. Lima<sup>1</sup>, Everaldo S. Júnior<sup>1</sup>, Mateus H. Torres<sup>3</sup>, Mohamed Boufaied<sup>2</sup>, Adem B. Zarb<sup>2</sup>, Mohamed A. B. Rekaya<sup>2</sup>, Iheb Zouaghi<sup>2</sup>, Dianne Magalhães Viana<sup>4</sup>

<sup>1</sup> Professional Master's Degree Program in Applied Computing, University of Brasília, Brasília, Brazil

<sup>2</sup> Esprit School of Engineering, Tunis, Tunisia

<sup>3</sup> Production Engineering, Faculty of Technology, University of Brasília, Brasília, Brazil

<sup>4</sup> Mechanical Engineering, Faculty of Technology, University of Brasília, Brasília, Brazil

Email: simoneborges@unb.br, khaled.hafaiedh@esprit.tn, joaomello@unb.br, anacristina.limafernandes@gmail.com, everaldo.junior@aluno.unb.br, mateushalbe@aluno.unb.br, mohamed.boufaied@esprit.tn, adem.benzarb@esprit.tn, medaziz.benrekaya@esprit.tn, iheb.zouaghi@esprit.tn, diannemv@unb.br

## Abstract

The traditional education in which the teacher introduces the concepts to be studied and students passively try to absorb the knowledge has been questioned. At the same time, the collaborative and inductive students-centred approaches, such as the Project-Based Learning (PBL), are gaining importance as students are increasingly concerned with obtaining competencies to deal with real-life situations, proposing solutions to problems and/or getting the most of the opportunities, by working in teams. In this context, a structured peer evaluation process is required to measure students' competences and create a solid feedback flow. However, the teachers have difficulties to effectively detect the student's strengths and weaknesses, making it challenging for them to help their students to develop the required competences. In this paper, it is presented the development of a digital solution for a structured, methodological and continuous process of Peer Assessment for students. This tool, denominated Peer-Assessment for Holistic Student Development (PAHSD), will be a module of the Platform for Unifying Methodologies of Active learning (PUMA), which is a platform for centralization and automation of PBL processes for university courses. With the PAHSD module, historical data from peer evaluation are used to identify which student's competences need to be improved and to measure which were already improved during his academic journey. The PAHSD indicates the specific training for personal improvement and allows students to compare themselves and also for the professor to make a complete analysis on students results. The PAHSD will be tested on PBL engineering projects in Brazil and Tunisia and could be extended to any education institution that adopt the PBL methodology in any area.

**Keywords:** Peer-Assessment; PBL Methodology; Machine Learning; Training via PBL.

## 1 Introduction

At the end of the university graduation period, students seem to have a growing concern about transitioning the skills and abilities they acquired during their undergraduate course to please the needs and demands of companies (Schoenau-Fog, Reng, & Kofoed, 2015). Many studies highlight that applying engineering courses into a real-world practical context brings many benefits to students (Cano, López, & Rebollar, 2008; Habash & Suurtamm, 2010; Tran & Nathan, 2010; Peterson, Hartmann, Fruchter, & Fischer, 2011). In this context, there is an increase in the use of inductive approaches, such as Project-Based Learning (PBL), which emphasizes that the teaching-learning process should be student-centered, meaning the students should assume greater participation and responsibility for their education (Prince & Felder, 2006).

PBL is part of the main educational vision at Esprit (Bettaieb, 2017). Project-Based Learning (PBL) has become the norm for modern education as an effective collaborative learning methodology for increasing motivation, engagement, and social presence of students involved in a project while maximizing time in dealing with real-world situations. Therefore, its application propels the university to work focused on making a real impact on society (Esprit, 2020).

The Production Engineering undergraduate program of the University of Brasília (UnB) acknowledges the importance of this scenario and cooperates with corporations for employee development to create a profile aligned with the professional practice. It adopts the PBL method, which embraces its eight units of Production

Systems Project (PSP) courses as well as undergraduate students' final projects (Monteiro, Reis, Silva & Souza, 2017).

Both UnB and Esprit are continuously looking for ways to ensure quality in the PBL application. In this context, the Platform for Unifying Methodologies of Active learning (PUMA) is being developed to support the application of the PBL method in the PSP courses in the Production Engineering Undergraduate Program at UnB. (Silva Júnior, Monteiro, Lima, Mariano & Silva, 2019). PUMA is a platform centered in academical culture and encouragement towards using Information and Communication Technology (ICT) as a useful tool to measure the efficiency of the PBL method, acquiring feedback and substantial and trustable information to redirect PSP courses over the years, besides watching market demands and maintaining the course always aligned to the stakeholder's expectations (Monteiro, Lima, Mariano & Silva Júnior, 2020).

Given this context, the structure proposed in this document seeks to answer the following research problem: how to use the module of a web platform to automate the peer evaluation process and, thus, improve the application of the PBL methodology? This article aims at presenting the development of the PUMA Peer-Assessment for Holistic Student Development (PAHSD) module, a structured, methodological, and with retrievable data digital tool. Since teams are the basis of work in the modern knowledge era, it is a growing concern that they work properly, meaning to have committed people with the correct skills and profiles to accomplish the expected results. The university plays a very important role in the evolution of individuals in both hard and soft skills, and PBL provides a more auspicious environment for that. Having the professor specific data about students' performances and, consequently, about their strengths and weaknesses is a key point to make possible more focused stimulus from the professor to the development of the students.

This article exposes the development of the peer assessment module of the Platform for Unifying Methodologies of Active Learning (PUMA). Everything from the justifications for choosing this problem, and treating it as an opportunity, to the development details is clarified in an organization line that includes Literature Review, Methodology, Development, and Conclusion. The literature review compiles the main researches that served as a foundation for development decisions. The methodology presents the information related to the iterations and dynamics of the international partnership, through which this project was developed, as well as the technologies and techniques used and how the project fits into the PUMA. In the Development topic, referred to as Platform for Unifying Methodologies of Active learning (PUMA) - Peer Assessment Module, the technical details are approached, including both Product Engineering and Computer Science/Engineering aspects. Finally, the conclusion reveals the results, lessons learned, and future project possibilities.

## 2 Literature review

The literature review comprises a group of important researched subjects that include the main existing knowledge in the search area. The procurement of a solid knowledge basis has been focused on the following topics: Project-Based Learning (PBL); Skills and Peer Assessment; and Platforms to support Peer Assessment.

### 2.1 Project-Based Learning (PBL)

The Project-Based Learning (PBL) approach emphasizes that the teaching-learning process must be student-centered, which means that the students must assume a more relevant role and accountability for their education, especially in collaborative executions of projects (Blumenfeld, Soloway, Marx, Krajcik, Guzdial, & Palincsar, 1991)

PBL method results show that it is a teaching approach designed to engage students in the investigation of real problems and the development of professional and human skills (Lima, Mesquita, Rocha, & Rabelo, 2017). The development of interdisciplinary skills, cooperation, project management, leadership, problem-solving abilities, among other aspects, is considered essential to building current engineers' training (Taajamaa, Kirjavainen, Repokari, Sjöman, Utriainen, & Salakoski, 2013).

The Project-Based Learning method has been increasingly tested and adopted in several educational institutions around the world (Condliffe, 2017). The PBL puts the student at the center of his/her learning

process during the execution of each project, which can be defined as a complex task, an opportunity, or a real problem whose execution involves research, planning, needs assessment, among other stages of development (Alfaro, Apaza, Luna-Urquiza, & Rivera, 2019).

## 2.2 Skills and Peer Assessment

PBL method is an educational approach designed to engage students in the investigation of real problems and the development of skills (Lima, Mesquita, Rocha, & Rabelo, 2017). The development of interdisciplinary skills, cooperation, project management, leadership, problem-solving abilities, among other aspects, is considered essential to building current engineers' training (Taajamaa, Kirjavainen, Repokari, Sjöman, Utriainen, & Salakoski, 2013).

Buhari, Valloo, and Hashim (2017) state that, from the employer's perspective, hard and soft skills are significant, being hard skills focused on technical knowledge, while soft skills are mainly based on communication, documentation, leadership and other personal skills.

A research conducted by Patacsil and Tablatin (2017) shows the gaps in soft and hard skills in students, starting from the perception of students and industry. For the authors, several studies relate ten common soft skills in the fields of business and computer technology. The soft skills are communication, critical and decision-making capacities, interpersonal skills, negotiation, problem-solving, self-confidence, self-management, teamwork, and worth ethics. A proposal for a professional development training program could help students to improve their soft skills and to get prepared for the market. On the other hand, Hard skills are used as a basis of the educational curriculum, attending the needs of the market. For example, to an Information Technology (IT) Program, the hard skills could be considered as standard software applications, knowledge of programming languages, databases, networking, and computer hardware, as well as the ability to design user-friendly graphical interfaces. The study focused on the gaps of soft and hard skills and selected the ones that would be more useful in an industrial environment.

The study Hwang, Hung and Chen (2014) reveals that peer review can improve students' achievements, motivations, and problem-solving skills, reinforcing the potential of peer assessment to help students make reflections that can help them to discover their learning problems and the possible ways to deal with them (Merrill and Gibert 2008). Self-assessment and peer assessment are becoming central aspects of student-centered education, such as PBL, becoming useful for developing essential skills for students, for example, taking more responsibility for their learning, developing a better understanding of content, evaluation criteria and their values and judgments, thus maturing a critical reflection skill (Wanner & Palmer, 2018).

## 2.3 Platforms to support Peer Assessment

Peer assessment is an effective tool for applying active learning methods. Students are stimulated to review themselves critically when performing a task or set of tasks, then communicate constructive feedback for each other's improvement. When examining the work of colleagues, students consider the significance of good work in general, especially if they use a detailed questions script as a guide (Schankman, 2015). Using peer assessment in group work can increase engagement, participation, and social presence in the course. In fact, students give feedbacks to each other, and the teacher can focus on more directed orientation. The key to receiving successful peer feedback is a constructive and honest environment in which students feel confident to share honest but useful constructive criticism about each other (Schankman, 2015).

As a previous step to the development, a research effort on the existing Peer Assessment platforms, which are here defined as any platforms that contain the Peer Assessment functionality for application in a teamwork educational environment, was carried out. The main two platforms that corresponded to the mentioned criteria were: Peergrade, a free online platform to facilitate peer feedback sessions among students (Peergrade, 2020); and PEAR (Peer Evaluation, Assessment, and Review), an online application developed by Teaching Support Services at the University of Guelph which helps instructors and teachers to apply peer assessment processes in their courses (Teaching Support Services, 2020)

The main qualities of the platforms were their functional effectiveness, being able to perform Peer Assessment surveys and store the data, and that they allowed students to access their own results. On the other hand, it

was evaluated that both had a lack of modern ergonomics, usability and simplicity, with unnecessary complexity within the allocation of teachers and students, and a lack of workshops or any other way to help students to improve their diagnosed weaknesses, and could be defined as professor-centred.

### 3 Research methodology

The Peer Assessment module design method is introduced in topics 3.1 and 3.2. The project was developed by students from Brazil and Tunisia with the supervision of professors from both countries. The following parts detail the workflow as well as the decision-making procedures in the development process.

#### 3.1 Method

As for the approach to the research problem presented in section 1, this study is a qualitative research concerning both the work and study areas of Esprit and UnB (Silveira & Córdova, 2009). In this context, the Case Study methodological approach was chosen, seeking to develop knowledge that allows the design and construction of the peer evaluation module, which had the participation of students and teachers from both universities. The Peer Assessment module was developed by Tunisian and Brazilian students and professors. Therefore, the methods that made possible the reported development reflect the terms of the partnership, as the steps of development describe below.

#### 3.2 Development Process of the PUMA Peer Assessment Module (PAHSD)

The PAHSD module was created to be integrated to the PUMA platform in the future. The development process of this module consisted of seven steps (Pressman, 2011), Figure 1

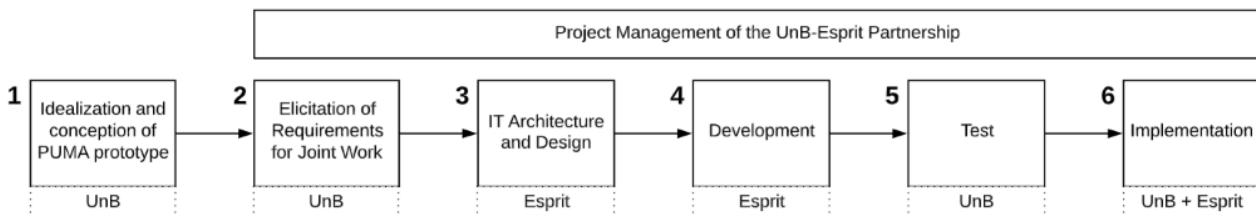


Figure 1. Steps of research.

The Peer Assessment module is designed to be added to PUMA. Seven steps organized the development process: (i) Idealization and conception of PUMA prototype; (ii) elicitation of requirements for joint work; (iii) IT architecture and design; (iv) development; (v) test; (vi) implementation.

##### 3.2.1 Step 1 - Idealization and conception of PUMA prototype

The beta version of the PUMA PAHSD module was developed applying the basic requirements in a prototype in Excel and was tested for 5 semesters in 1 course, denominated Production System Project 5 (PSP5), of the UnB production engineering undergraduate program. Each student received a spreadsheet with the name of all members of his team (his own included) and should evaluate himself and the others in 20 different micro-skills related to 6 macro skills like communication, leadership, effectiveness, professionalism, manageability, and cognitive abilities. The spreadsheet was applied in two different moments of the course: in the middle and one week before the end. Thus, the students' progress was recorded, and it was also possible for the teacher to intervene in the student teams to remedy possible problems when the evaluation result isn't good. The result of the peer assessment is necessary to improve the students' skills. Besides, a prototype in HTML was developed for the front-end, which included the same functions as Excel, including now the enhancements from the PSP5 cycles of validation.

##### 3.2.2 Step 2 - Elicitation of requirements for joint work

Identifying the requirements of a problem is a major challenge for system developers (Pressman, 2011). The engineering requirements help to communicate the expected effects of the software on the company and support product development. This step involved three parts, from identifying requirements to documentation, as described below:

- **Requirements identification and analysis:** This phase included the collection of requirements, by identifying, through interviews and brainstorming, target group needs with the project participants.
- **Requirements specification:** It included the assignment of all functions required for the complete set-up of the software based on the use case diagram.
- **Requirements Documentation:** This phase was accomplished by fully describing the requirements of each assigned functionality, including all of the following details: Purpose of functionality; Prototype; Pre-Conditions; Business rules; and Messages.

### 3.2.3 Step 3 – IT architecture and design

For the architecture, the MERN Stack Development was used. The main advantage for developers using the MERN stack is that every line of code is written in JavaScript. This is a programming language that's used everywhere, both for client-side code and server-side code. With one language across tiers, there's no need for context switching, Figure 2.

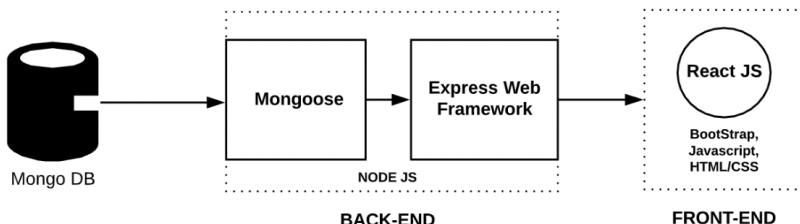


Figure 2. Technologies adopted in the module development

- **Front-End Development (React):** As a JavaScript library for building user interfaces, the React library can be used for creating views rendered in HTML.
- **Back-End Development (Node.js):** It's designed to build scalable network applications, and can execute JavaScript code outside of a browser.
- **Database (MongoDB):** It is a NoSQL (non-relational) document-oriented database. Data are stored in flexible documents with a JSON (JavaScript Object Notation)-based query language.

### 3.2.4 Step 4 – Development

For the development methodology, SCRUM, an agile methodology with incremental characteristics, was chosen. At this project management method, the work is divided over several time slots called sprints until the achievement of the project as a whole. Each increment is integrated into the components of the previous sprint, connecting the different development stages. At each stage of the development process, the product is implemented, tested, and then integrated (Scrumstudy, 2016), Figure 3.

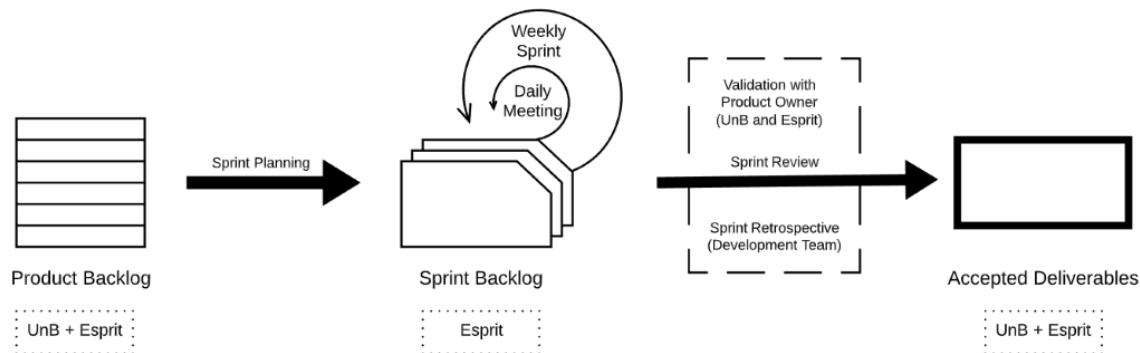


Figure 3. Scrum Methodology applied in the project

Scrum methodology proposes quick and frequent meetings. There were during this project daily meetings with all the team members, and a weekly meeting with the scrum master and the Brazilian team to discuss the project progress. Discord was used as main communication tool to keep track of each other's work, and GitHub was used for the integration of the work.

### 3.2.5 Step 5 - Test

As a previous phase to the release of the module for proper use in project-based learning courses, testing sections with the development team is essential. A university course environment is simulated and fictional teams with project members are created to anticipate the user experience and ensure that the front and back ends are functional. All functional situations have been tested by the development team and the other APIs in BackEnd have been tested with Postman.

### 3.2.6 Step 6 - Implementation through Engineering Courses

This step consists of the validation and improvement of the module developed. It will include two engineering teams from UnB and Esprit who, during the second semester of 2020, will work on diagnosing the functionalities and verifying the effectiveness of the PAHSD. In this step, it is expected to raise new requirements, test and refine the features developed, and implement the changes. Thus, obtaining a version of the module that is ready to be applied in PBL courses.

## 4 Platform for Unification of Methodologies of Active Learning (PUMA)

### - Peer Assessment Module

The Platform for Unifying Methodologies of Active Learning (PUMA) was conceived to an A3M (Learning for the 3rd Millennium) Program of University of Brasilia (Monteiro, Campos, Lima, A & Mariano, 2018). In 2018, the Brazilian team developed two modules: the first was related to project management and the submission of projects by stakeholders (companies, for instance); and the second was the module for the publication of news in the platform (Silva Júnior, Monteiro, Lima, Mariano & Silva, 2019). In 2020, the other two modules of PUMA, Peer Assessment and Team-Building have been developed by a multidisciplinary team composed of students and professors from Tunisia and Brazil. The main structures of the Peer-Assessment for Holistic Student Development (PAHSD) module with a description of the functionalities and exposure of the development stage of the front-end can be understood in 5 main parts, as presented in the following sections.

### 4.1 Module developed and technical information regarding the Peer-Assessment

Students generally have a good understanding of one another and peer assessments allow them to share perceptions on each other's areas of mastery and weakness. By doing so, they discover ways to overcome their obstacles and address deficiencies in ways that work best for them, instead of through prescribed interventions provided by a teacher. The success of the evaluation is closely related to how much the students adopt standardized criteria and processes. Subsequently, the teacher takes part in it by adding workshops targeting the weaknesses of the majority of his students, as well as challenging students with specific weaknesses to take positions that push them to solve these gaps. By doing so, he makes sure the student develops holistically in macro skills and have the actual achievement of their potential.

#### 4.1.1 Registration/Profile

The student and the teacher need to register to the application. Then, the administrator, after checking the information with the university, decide to give or deny access to the application. After getting the validation from the admin, they both can update their profile and add the needed information, Figure 4.

The screenshot shows a registration form with an orange header labeled 'Email'. Below it are three input fields: 'First Name' with placeholder 'Nom', and 'Last Name' with placeholder 'Last Name'.

Figure 4. Registration of Users

#### 4.1.2 Add Skills

The teacher can also add any macro skill wanted and immediately include it as a peer assessment criterion to a group of projects, being a hard or a soft skill, Figure 5.

### Add Macro Skill

Name

Description

Hard Skills

**Add MicroSkill for This MacroSkill**

Figure 5. Add Macro Skill and Micro Skill

#### 4.1.3 Peer Evaluation Process

After logging in, the student can proceed to the Peer Assessment by just choosing one of the projects he's participating in. After selecting the project, he will be able to evaluate all the members engaged in it. If he already had assessed his teammates, he won't be able to do it again. Else, if he/she hadn't done it yet, after clicking on the Evaluate button, the peer evaluation Form, Figure 6, will open with permission to fill in.

		<b>macro skills</b>	<b>micro skills</b>
Teammate Boufaied Mohamed	Teammate ben rekaya aziz	Communication	Timeliness of information provided <input type="checkbox"/> No Effectiveness of means of communication <input type="checkbox"/> No
<b>EVALUATION!</b>	<b>EVALUATION DONE!</b>		

Figure 6. Step of Peer Evaluation Process

The Evaluator needs to grade every micro skill using a behaviourally anchored, 6 scale rating (Excellent =5, Very good = 4, Satisfactory = 3, Ordinary = 2, Unsatisfactory = 2, No show = 0). After everyone in a team having evaluated the other and himself, every student can check his evaluation from the project. He would be also able to compare his results with his teammates with a comparation graph, this Figure 7.

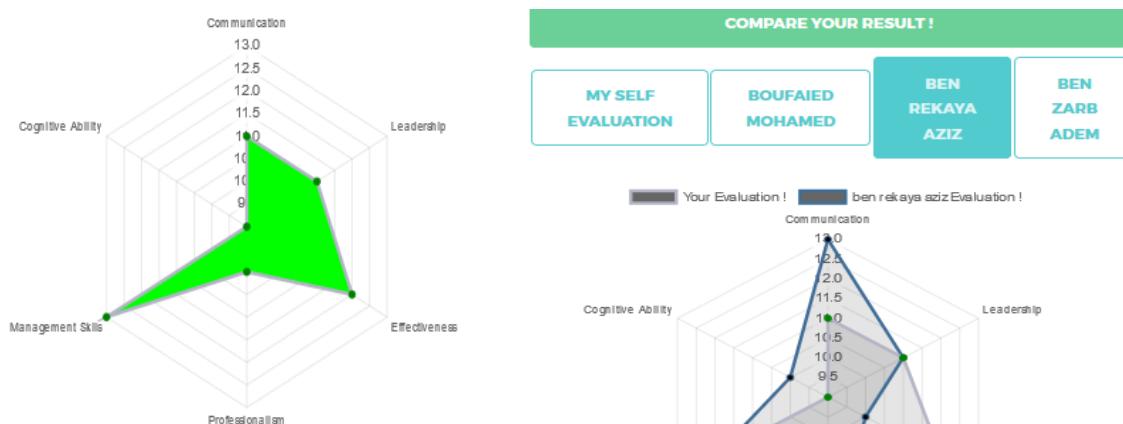


Figure 7. Comparison of your evaluation with the teammate

The teacher is able to keep track of the students and check their performances, comparing their results in, for instance, student-student and student-average models, and check the best evaluation per macro skill. The professor can also compare a student's performances in different projects over time, Figure 8.

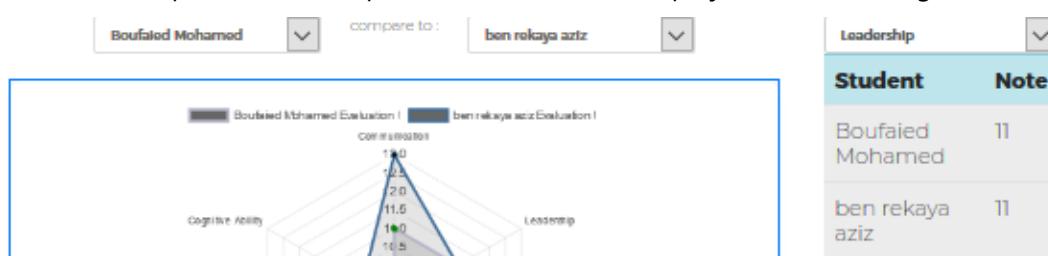


Figure 8. Comparison of student evaluation per Macro Skill

#### 4.1.4 Workshops

The teacher can also add a workshop targeting the general weaknesses of students in any micro skill. Every workshop has a description of the specific skill, a date for its occurrence and a limit number of participants.

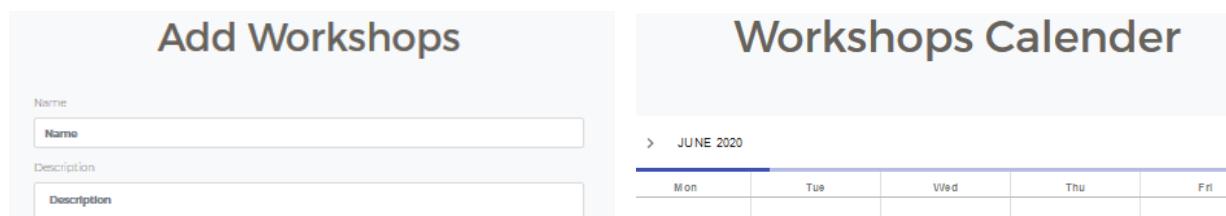


Figure 9. Suggested workshop for Macro Skill to be developed

After adding the workshop, the students can visualize the complete list of planned workshops in a calendar, in which they can select to participate in the workshop or not.

## 5 Conclusion

The tool developed in this project as a PUMA module in the context of the Brazil-Tunisia partnership corresponds to the requirements to solve the teacher's scarcity of student performance information. The PAHSD empowers educators them not only to direct efforts towards student skill evolution, but also to have a quick diagnose on project teams that are underperforming, thus maximizing the efficiency of the whole Educational system.

Therefore, with the development and presentation of a support module for peer evaluation in the PBL context of UnB and Esprit universities, the objective of this research was achieved, having also answered the main research question investigated, by means of developing the platform and using it to automate processes in educational environments.

This partnership between Brazil and Tunisia evidenced important possibilities of real achievements with international entrepreneurship in the University context, with win-win ties. Brazilians had a project of a platform that assesses the students in the active learning process, and the Tunisians had the computer science skills to carry out the development. The joint work was the key to transform these latent possibilities into one unified concrete result.

The evolution of the student's competencies and skills occur over time and not only in one course. Therefore, it is important to have a standardized amount of a peer evaluation system that utilizes the same criteria over time in order to allow the comparison of historical data in short, medium and long-term. PUMA as a centralized multi-courses platform having the PAHSD module will allow a proper understanding of the evolution of the students' performances and, consequently, of the educational approaches applied, allowing continuous improvement.

The final implementation plan of the PAHSD module developed will be carried out in three to five courses that use active methodologies, at least two in Brazil and one in Tunisia. This test consists of a complete simulation of the application of the module in the course and provides a full-functional version of the module, hosted on a temporary PUMA server in Brasilia. The students will be required to register and establish their teams into the platform, in a way that they can start their project and will peer assess each other at least 3 times during the semester. In the end of the course, the professors and students will be submitted to a survey to evaluate their respective environments in the module, in order to provide feedback. The team will then evaluate the feedbacks received and proceed to the next phase, which is the improvement.

PUMA's peer assessment functionalities are mainly contemplated by this project, but many usability and data management functional will require future work with an incremental approach. The other modules of PUMA are also future work to be developed through the Brazil-Tunisia partnership framework, established by UnB and Esprit.

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