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Team Building through Student's Preferences and Competences (TBSPC): implementation on a PBL platform

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Abstract

Project-Based Learning (PBL) has been widely used in education, helping students to develop technical knowledge within a critical thinking, collaboration, creativity and communication environment. Thus, PBL has the students as the main object, enabling them to decide on real-life focus situations, proposing, through teamwork, solutions to problems and/or getting the most of the opportunities. PBL promotes enjoyable learning, allowing the direct mandatory participation of students, teachers and the owners of the real-life situations under consideration, as well as the eventual participation of other relevant stakeholders. However, in most cases, the choice of teams is made manually by the teacher, through criteria that many times result in lack of coherence and equity between the project teams. This undesirably affects the overall group performance due to conflicts, communication gaps and lack of transparency. In this paper, a flexible module is proposed to digitize and automate team-building processes, based on students' preferences and competences. This module, called Team Building through Student's Preferences and Competences (TBSPC), may be applied to any type of PBL project and offers to students the possibility to contribute in the PBL team pre-creation phase, allowing their decision-making based within some settings previously established by teachers. This makes PBL teams coherent, complementary and congruent with the project. The effectiveness of the mechanisms for creating teams and their impact on the teams' performance in PBL courses are a focus for the TBSPC module development in the context of the Brazil and Tunisia partnership. This module will be part of the Platform for Unifying Methodologies of Active learning (PUMA) which is a platform for centralization and automation of PBL processes for university courses.

Keywords: Team Building; Student´s Preferences and Competences; PBL Methodology; PUMA.

1 Introduction

Problem Based Learning (PBL) is a student-centred, collaborative, non-traditional approach to education in which students learn about a subject through the experience of solving an open-ended problem as a central place in the learning activity (Adderly, 1975; Prince & Felder, 2006). However, PBL is not always successfully implemented as students are constantly challenged to unlearn old learning habits to make way for new learning styles collaboratively (Meireles & Bonifácio, 2015). Pitfalls such as social distraction, groupthink, overdependence on a dominant leader, overcommitment to goals, and diffusion of responsibility are challenging key factors that may reduce team effectiveness when teams intentionally focus on Project Based Learning (Kayes, Kayes, & Kolb, 2005). To learn from their experience, teams must create a conversational space where members can reflect on and talk about their experience together (Martins & Frezatti, 2015).

Since its foundation in 2003, The Private Higher School of Engineering and Technology ESPRIT embraced the PBL methodology by having students working on projects and real problems during the entire graduation period, to enhance their engineering reasoning skills before they graduate (Bettaieb, 2017). Since its beginnings, Esprit implemented PBL courses and curricula agreeing that, as an outcome of the PBL process, students have greater retention of learning and increased ability to apply knowledge in engineering settings. By using the Project Based Learning method, the students become intrinsically involved in their training and education. This is one of the reasons why Esprit obtained the EUR-ACE accreditation provided by the French organization CTI (Committee of Engineering Titles) in September 2017 (Esprit, 2020).

The Production Engineering Undergraduate Program of University of Brasília (UnB) has also acknowledged the benefits of education through real-world problems and its power to cooperate with the market by developing students with the holistic skills, both hard and soft. It adopts the Project Based Learning (PBL) method, especially in the eight Production Systems Project (PSP) courses and in the final graduation projects developed by students (Monteiro, Reis, Silva & Souza, 2017). PBL aims to make students apply theoretical knowledge by solving real issues, by which they are instigated to learn. In all stages of project development, from planning until closure, they need to acquire different kinds of knowledge and understand the many dimensions involved in the problem-solving process.

In the context of ensuring proper application of this methodology, the Platform for Unifying Methodologies of Active Learning (PUMA), a digital platform that structures and automates PBL processes in university courses, was idealized at UnB as an opportunity to optimize PBL application (Silva Júnior, Monteiro, Lima, Mariano & Silva, 2019). A Brazil-Tunisia partnership for PBL project-development started at the 11th International Symposium on Project Approaches in Engineering Education (PAEE) and at the 16th Active Learning in Engineering Education Workshop (ALE) which took place in Tunisia in 2019. In the beginning of 2020, the partnership was already mature and there was an agreement to include Esprit in the PUMA development. For both universities, PUMA represents a way to ensure quality in the different PBL courses, by standardizing and centralizing procedures and information as well as connecting the market to the university, bringing real clients and problems to the student teams working in the PBL framework.

The courses that use the project-based approach adopted by the courses at the University of Esprit and the University of Brasilia, generally adopt different procedures for the division of teams, obtaining varied results. Some courses at these universities often divide teams randomly; after that, students choose a project after a short time of getting to know each other. Therefore, some students may not be satisfied with their team members or even hold teachers responsible for any relationship problems between team members. It should also be noted that students can be happy because they can work with people to whom they have affinities, but they need to make smart choices about the proposed topics to have the chance to be contemplated with team members who want to work together.

Another important point is that, in many courses at Esprit and UnB, the allocation of team members does not consider the necessary competencies in advance. Therefore, some problems may arise during work, as the team lacks the skills and knowledge required for developing the projects. In these cases, students may have problems with the lack of certain competence in the team, which can affect the performance of the project, giving rise to a dysfunctional group. This can be a problem for the progress of the project, as it can create an unceasing atmosphere of creative tension. It is in the face of these pedagogical aspects that team building through students' preferences and skills should be applied in the classroom, to encourage collaboration, problem-solving, and decision making through the creation of teams more efficient.

This article aims at presenting the results of the development of a methodological digital tool to the PUMA team building module. Since teams are the basis of work in the modern knowledge era, it is a growing concern that they really bring together people with the proper skills and profiles to accomplish the expected results. To establish a solid process that matches some of the basic requirements for the process concept, such as to be repeatable and provide trustable and standardized results, a computer science digital platform was created and this article presents its development.

Everything from the justifications for choosing this problem/opportunity until the development technical details is clarified in an organization line: The literature review compiles the results of 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. In the Development topic, referred to as Platform for Unifying Methodologies of Active learning (PUMA) - Team-Building Module, the technical details are approached. Finally, the conclusion reveals the results, lessons learned and future project possibilities.

2 Literature review

The literature review encompasses a group of key research points that support the development of the work. The focused themes for the acquirement of a solid basis for the project were PBL, from which the methods to be inserted in the platform come, specifics about students' competences and preferences surveys, which are the basic criteria for the team building, and search of the existing digital platforms with team building functionalities.

2.1 Project-Based Learning (PBL)

The Project Based Learning allows students to learn pushed by a problem that cannot be solved with the current level of knowledge and/or way of thinking about the issues (Araújo, Rodrigues, Silva, & Soares, 2015). Therefore, working for an extended period of time to investigate and respond to a real-life problem is crucial to produce further ideas/hypotheses and learning issues to acquire necessary knowledge and skills required to make reasonable judgments about solving the problem (Margetson, 2001).

There are several student-centred teaching strategies, one of them is the Project-Based Learning (PBL), as students are able to build their knowledge, alongside their professors, through the execution of projects about various themes (Torres & Irala, 2014).

Buhari, Valloo and Hashim (2017) emphasize that a strong relationship can be built between university and industry/company through projects, enabling benefits as follows:

- Companies gain low-cost access to college's skills and infrastructure, as well as high-performing students and professors.
- Companies can meet students' abilities for employment.
- Students can better understand the company's problems, processes and technical requirements, increasing their skills before graduation.
- Students can learn creative approaches to solve real problems of companies.
- Universities can develop strong and continuous partnerships with the companies, which are mutually beneficial, as they help each other by building and sharing knowledge through students.

2.2 Preferences and Competencies of Students

Students have individual preferences and competences, insomuch that they have different ways of how they perceive and process information. These individual preferences and competences are called Learning Styles (Alfaro, Apaza, Luna-Urquizo, & Rivera, 2019). Learning Styles are personal qualities that influence students' abilities to acquire information, interact with others and enabling them to participate in learning experiences (Agudelo, Urbina, & Gutiérrez, 2010).

Students tend to focus more on acquiring human competencies, such as leadership, communication and collaboration, since these cannot be assumed by autonomous machines, especially in the advance of Industry 4.0 (Panthalookaran, 2018). However, hard skills, centred on technical knowledge, are still significant for companies (Buhari, Valloo & Hashim, 2017)

Individual preferences and competences affect team building based on their interest in the project proposals and what type of group students want to have (Jensen, 2018). Teams are a primary mechanism for executing an organisational work. Consequently, team building, team size and cooperation are critical factors in a PBL project execution (Kim, 2018).

2.3 Platforms to support Team Building

Non-digital executive control doesn't allow continuous and precise monitoring of teams as the digital does, being, thus, essential the availability of a platform that supports all the involved processes in achieving effective PBL application. Before developing the Team Building through Student's Preferences and Competences (TBSPC) module, it was carried out a thoroughly analysis of the existing platforms on the market, looking for inspiration and to identify their possible shortcomings and the areas in which they need improvement. The targeted platforms were the ones that had team building functionalities and were focused on students' projects.

The main three platforms that conformed with the cited criteria were: Cloverleaf, a famous platform for team management (Cloverleaf, 2020); Crowdschool, a popular Project-Based Learning platform (Crowdschool, 2015), and Team Building Support System (TSS), which supports students in PBL courses to organize their teams effectively (Kim, 2018).

However, these three platforms have the same bottleneck, which is the absence of any kind of means of communication, and students have no way to interact, manage tasks and make key project decisions. Thus, it is necessary to develop a platform that allows more effective communication, interaction among students and management of teams, focused on the PBL methodology.

3 Research methodology

The research methodology is presented in topics 3.1 and 3.2. The section 3.1 presents the research method and the section 3.2 shows the step by step of the team building module development. Workflow detailing as well as decision-making paths in the development process are subsequently presented.

3.1 Method

This research presents a case study with qualitative approach, involving Esprit and UnB. The team building module was developed by Tunisian and Brazilian students and professors. Therefore, the configuration of the partnership itself is directly connected to the methods that allowed its creation. The development of the module followed the coming steps that will be detailed in section 3.2.

3.2 Development Process of the PUMA Team Building Module

The development process involved seven steps, based in software engineering concepts (Pressman, 2011), Figure 1.

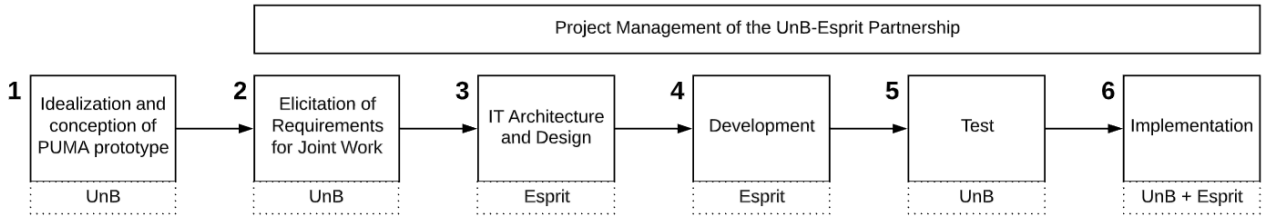

Figure 1. Steps of research.

The Team Building Module will be added to the PUMA platform. The development process involved seven steps: (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. All the mentioned steps were already complied, except for the (vi) implementation. These steps are described below.

3.2.1 Step 1 - Idealization and conception of PUMA prototype

The Beta version of the team-building module was carried out in Microsoft Excel and has been developed and pre-implemented in a project-based learning course (PSP1) in the production engineering undergraduate program at UnB. The initial formation of the Project Groups defined by the PSP1 2019/2 coordination was then submitted to the preferences of each of the 54 enrolled in relation to the (i) 14 Project contents; and (ii) classmates with who each would like to work as a team. To collect such preferences, each student answered 3 questions on a Questionnaire of Preferences, that constituted the basic requirement for the TBSPC module development: 1-Select your name: 2-Answer on project preference; and 3-Indicate the 6 classmates you would preferably select to work on your project team.

Furthermore, there was a prototype developed in HTML for the front-end, which encompassed the same functionalities of the above-mentioned Excel implementation, but with the improvements from the Excel experience. For both Excel and HTML versions, students would be allocated in teams based on prioritization of (i) and (ii) combined.

3.2.2 Step 2 - Elicitation of requirements for joint work

According to Pressman (2011), understanding the requirements of a problem is among the most difficult tasks faced by system development professionals. In this way, the requirements engineering tasks, help to bring the understanding of what the impact of the software on the business will be and support the construction of the product with the development team. This step, comprised performing of 3 phases, from the elicitation of the requirements to its documentation:

- **Requirements elicitation and analysis:** This phase comprised the survey of requirements, by understanding and identifying needs with project stakeholders, through interviews and brainstorming.
- **Requirements Specification:** It covered the mapping of all necessary functionalities for the complete construction of the software, through the use case diagram, in which it was possible to identify all of them for the complete construction of the product.
- **Requirements Documentation:** This phase was carried out, through the complete description of the requirements of each mapped functionality, comprising all details: Purpose of the Functionality; Prototype; Pre-Conditions; Business Rules, and Messages.

3.2.3 Step 3 – IT architecture and design

The topics below compile the main technologies and details over the development of the software architecture, Figure 2.

- **Databases:** the main technology applied was MongoDb, a NoSQL database that offers many benefits over relational databases. NoSQL databases have flexible data models, scale horizontally, have fast queries, and are easy for developers to work with.
- **Front-End:** the main technology applied was React JS, an efficient, declarative, and flexible open-source JavaScript library for building simple, fast, and scalable frontends of web applications.
- **Back-End:** the main technology applied was ExpressJS, a prebuilt NodeJS framework for, among other functions, creating server-side web applications.

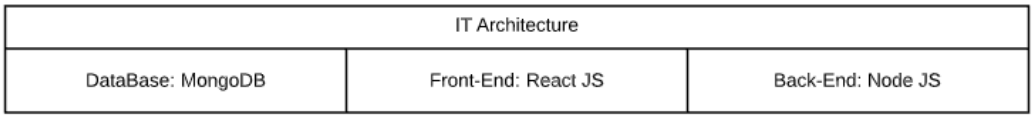

Figure 2. Technologies used for module development

The recommendation is based on the preferences and previous experiences of students, required competencies for development projects, and a measure of similarity to other students. The main steps of this approach are: (I) Students' previous experiences. and preferences and required competencies on each project are saved; (ii) a subgroup of students is identified whose experiences and preference are similar to those of the user (student) seeking the recommendation and competencies required on projects; and (iii) the resulting preference function is used to recommend students to the platform user looking for the recommendation. Thus, after gathering the needed data from students' profiles and the projects created, the recommendation algorithm starts automatically within the application to give a list of candidates that their skills, previous experiences, and preferences match the required ones for the project. In this way, this algorithm consists of optimizing team-building by bringing together people who would like to work together on a topic they appreciate. It can maximize the performance of the project from the beginning.

3.2.4 Step 4 - Development

For the development methodology of the module, SCRUM, an agile methodology with incremental characteristics, was selected. 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. At each stage of the development process, the product is implemented, tested and then integrated (Scrumstudy, 2016), Figure 3.

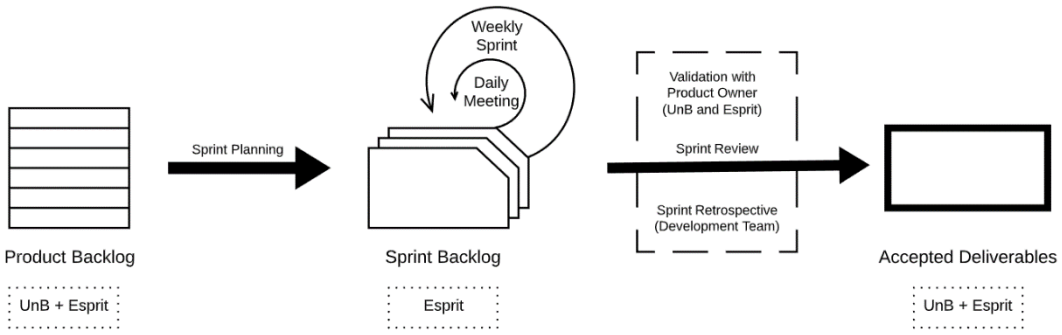

Figure 3. Methodology applied in the project management

In the present case, Scrum was adopted with some modifications, in view of the context in which the project is inserted. The main Framework ceremonies such as daily meetings (development team) and weekly meetings with our scrum master (professors) and the Brazilian team (product owner), and Trello, a web-based Kanban-style list-making application, was used to keep track of our progress during the development period, with GitHub for the work integration. Ceremonies and techniques such as Sprint Planning, Sprint Review, Sprint Retrospective were carried out according to the official Scrum Framework.

3.2.5 Step 5 - Test

Before releasing the module for proper application in project-based learning courses, it is important to submit the software to a group of tests with the development team. This is done by simulating an university course environment and making fictional teams with the members of the project to reproduce the user experience and guarantee that both the front and back-end are functional. All of the functional scenarios were tested thoroughly by the development team by testing the rest APIs in the Back-End using Postman.

3.2.6 Step 6 - Implementation through Engineering Courses

This phase is planned to involve a cycle of improvement during the second semester of 2020 when two engineering teams from UnB and Esprit will work on diagnosing the functionalities and verifying the effectiveness of the TBSPC. This validation consists of a complete simulation of the module hosted on a temporary PUMA server in Brasilia. In this step, it is expected to raise new requirements, test and refine the features developed, and implement the changes.

4 Platform for Unifying Methodologies of Active learning (PUMA) - Team-Building Module

PUMA is being developed to support the application of the PBL method along subjects at universities. It 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 (Silva Júnior, Monteiro, Lima, Mariano & Silva, 2019). Providing and receiving feedbacks in easier and more standardized way is also a focus, with substantial and safe information to redirect PBL courses over the years (Monteiro, Campos, Lima, A & Mariano, 2018). It also allows continuous alignment with market demands for students' capacities as the platform involves companies in the university PBL activities.

It can be understood that the PUMA Platform is a tool that integrates input and results of the projects developed by students along their graduation period, being the entrance door to the stakeholders' demands to be investigated by students in real problem-solving situation (Monteiro, Lima, Mariano & Silva Júnior, 2020).

4.1 Module developed and technical information of Team Building through Student's Preferences and Competences (TBSPC)

This section presents the main structures of the software developed with a description of the functionalities and exposure of the development stage of the front-end. The Team Building module can be understood in 5

main parts: creating an account and a profile; project assignment and group creation; project creation and validation; team management; and Voting System and means of communication.

4.1.1 Creating an account and a profile

Each applicant will create their own account by simply signing up into the application and, after validating their accounts by email verification, the user will complete his own Profile by adding his previous experiences, educational background, skill set, social media, and other details about them, Figure 4.

Figure 4. Create profile and add experience interfaces

4.1.2 Project assignment, group creation and validation

After having their Profiles completed, applicants will be able to create their own groups, by choosing a project that has pre-edited settings, and add other members. The application will recommend other applicants based on their skills and background. After submitting the application, the group needs validation from the admin. Teams are deleted if not enough people join within 48h from its creation. Figure 5.

The teachers, stakeholders, and admin users are able to create projects by filling the specified form: the name of the project, documentation and required skills, as well as the voting system, if the creator already wants to define it (students can also be responsible for the choice). After this process, the project needs to be validated by the administrator so it can be visible for the students, Figure 6.

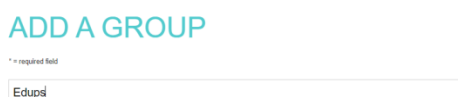

Figure 5. Add a group interface

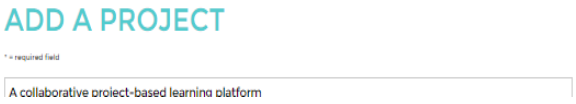

Figure 6. Add a project interface

4.1.3 Team management

While the group creator is choosing the team members, the application gives him a set of suggestions based on the competences and skills needed for that specific project. The group creator will have a matching set of skills with the ones required for the project. The team leader is the member who created it in the system. After the team is assembled, the members can change the leader by having a vote section or the responsible teacher/instructor can select manually another team leader.

There are three possibilities for participants who are not in any group and who missed the deadline: the first one is to send a request to an existing group and, if they haven't reached the maximum amount of students yet or are missing one to complete the team, the group members can vote and either accept or reject his/her request; in the second option, members of one existing group send an invitation to the participant to join their group; in the third option, the teacher can add any participants to any group if he/she decides to do so, Figure 7.

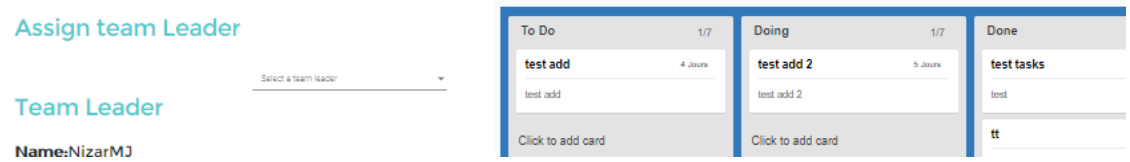

Figure 7. Assign team leader by teacher and Trello

The students are able to continue using the platform while working on their project by having an embedded Trello application within which they can divide the work into tasks and making sure to have continuous progress. The professors have access to project Trello boards.

4.1.4 Voting System and means of communication

To ensure the fairness, equitability, and equality between the team members, the platform contains a voting system. It covers many conflicts between members, including decision-making controversies. The voting form is composed of a vote title, subject, and choices that could be yes or no, or multiple choices based on the voting type that the groups have chosen from the beginning, Figures 8 and 9.

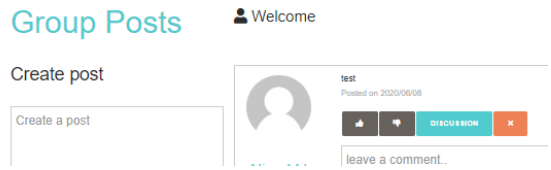

Figure 8. Communication and vote interface

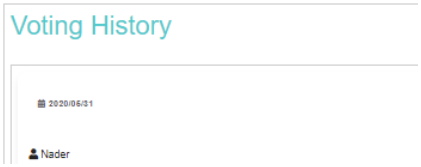

Figure 9. Voting history interface

By putting the power in the hands of the students, since they can choose their partners, distinguished by their specific skills (soft or hard), the TBSPC allows the enrolled students to deny or accept new applicants. The lack of central authority or external entity imposing decisions improve students decision-making capabilities. As a productive team needs a lot of daily communication and workflow control, the platform also provides a timeline and an optional voting system.

5 Conclusion

Team Building through Students Preferences and Competences (TBSPC) module would represent progress to PBL projects, since it encourages organic collaboration, by joining people with already stablished relationships or ties, and by having them working in projects in which they genuinely believe. It is a web-based system to manage group creation, project assignment and project management. Administrators can add any kind of actor, instructors, students or courses to the database. Instructors can add new projects and attach any kind of files to them to provide all of the needed details.

Teamwork is a fundamental part of PBL's differential in relation to traditional methods. It promotes collaborative learning, given that students can learn from each other's work and pinpoint the aspects in which they need improvement, and simulates the market projects and any project with an environment of uncertainty and complexity. This provides the students with real project experience, as well as increases the university position as a value deliverer to society. To maximize the results in this context, a platform that structures and automates team building is an element that not only brings more efficiency to university initiatives and projects, but also tends to improve and optimize the entire educational process.

With the development of a support module for creating teams in educational environments, the objective of this research was achieved. However, it is worth remarking that the limitation of the research is in proposing something that is focused on the context universities, not considering the business environment, even if most organizations face the same challenge of team building and would not have the possibility to select members based on precise criteria. Therefore, the application and evaluation of this module for the job market is suggested as future work, in addition to a study focused on how to improve the necessary the students' skills to deal with dysfunctional teams in professional environments. These skills must be developed even in courses that will apply the proposed module.

Another important suggestion for future work is the presentation of the results of the team creation module, after applying the validation and evaluation methodology proposed in section 3.2.6 in the workshop and courses because until the end of this study it was not used in the context of a real-life situation. PUMA's team building functionalities, including further automation, possibly with team allocation using AI data driven decisions is already a proposal for future works on the TBSPC module. The other modules of PUMA will also be developed through the Brazil-Tunisia partnership framework, stablished by UnB and Esprit.

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