

Towards the professionalization of students through the application of anew PBL approach

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Abstract

Project-based learning (PBL) has always aroused the interest of teachers who are keen to adopt an active pedagogy that puts students at the center of the learning process and promotes what is called "learning by doing". And although the principles of PBL are clear and unambiguous, its implementation in practice can run into some difficulties. The purpose of this paper is to present a new approach based on a practical model that will serve as a guide for teachers who want to implement PBL. This approach includes the steps to be followed, the tools to be used in each phase and specifies the different stakeholders involved in the process and their respective roles. To illustrate how to implement this new approach, we will be presenting a case study showing how we applied PBL in the module "Integration Project" targeting computer science students at the Higher Institute of Technological Studies of Beja (ISET). This implementation allowed us to evaluate the impact of our approach on the students' skills and on the quality of their final projects. The evaluation surveys that were conducted in this regard revealed a qualitative leap in the quality of the end-of-studies project (PFE) in terms of the advanced technologies used and an increase in the technical and transversal skills of the students

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1. Introduction

At odds with the classical pedagogy based on the passive transmission of knowledge where the teacher exposes his knowledge to students and which starts from the theory to go towards the practice, the active pedagogy admits the principle "it is by doing that we learn", and places the learner in the center of his learning process by supporting his implication and his motivation so that he can build his knowledge through situations of experimentation [1]. Problem solving, role-playing, case studies, critical debates and other active pedagogy approaches are just a few examples of methods used in academia to actively engage students in their learning by allowing them to reflect, criticize, evaluate and create, while fostering collaborative work.

Among the methods likely to improve the motivation and involvement of learners is Project Based Learning (PBL). It is an active socio-constructivist teaching practice that allows the acquisition of new knowledge through the production of a concrete project [1]. In Tunisia, the application of PBL was first initiated by the Private Higher School of Engineering and Technology (ESPRIT), in September 2012. This first initiative was based on international studies and comparisons of some PBL models used in different

universities, such as those used at the University of Sherbrooke in Canada and the Catholic University of Louvain La Neuve in Belgium. The application of this pedagogy has been very successful and has led to good results in improving the skills of students at ESPRIT [2], [3], [4]. In the literature, we noted the absence of research and studies that could give guidelines on the application of PBL in Tunisian universities. Only a few research works have been carried out by teachers and researchers at ESPRIT in order to highlight the richness and importance of the experience they have conducted. According to Potter and Louati in [2], PBL is one of the best pedagogical approaches that combines the theoretical and practical aspects while developing the student's language skills. Their study was oriented towards active English language learning through group work, presentations, debates and many other communication activities. In [5], the authors, who are none other than students of the civil engineering specialization at ESPRIT, noted several positive contributions of the application of PBL during their academic training on a personal and professional level. In [4], the authors presented the experience of PBL application with Business Intelligence (BI) students. The experience described in [4] was conducted in collaboration with

professionals who proposed the projects and participated in the supervision of the students. The results of the surveys presented in [4] showed that students pay more attention and invest more effort in this type of project. Unfortunately, despite the importance of the experiment that was conducted through the application of PBL, the approach described in [4] could be exploited only for students with the BI specialty. Moreover, the works described in [3] and [4] focused on the presentation of PBL application experiment for certain specialties and on the analysis of the results obtained. The approach used to succeed in this experiment remains unclear, absent, or even difficult to apply or follow despite the wide range of different experiments and the positive results obtained.

In this article, we will first detail the theoretical foundations of PBL and the classical approach to its implementation. Then, we will expose a new approach that provides a well - structured framework that could be adapted to fit the application of PBL in any discipline. Our approach aims to align the curriculum with the needs of the labor market while relying on a close collaboration with professionals. This allows us to promote the employability of students and facilitate their integration into the professional world. The approach that we

presented in this paper also proposes a hand-on solution to solve the problems related to the organization, the coordination between the various participants, the follow-up of the students and the evaluation of their work. Finally, we will be presenting a case study that illustrates a progressive application of our new approach at the Higher Institute of Technological Studies of Beja. The case study is followed by an analysis of the results obtained, as well as possible improvements and perspectives.

2. The fundamentals of project-based learning theory

PBL, project-based learning, project-based approach, project pedagogy, project-based teaching, project-based learning are all similar designations. This approach consists in students carrying out a concrete project close to the professional reality, alone or in groups, under the supervision of the teacher. In the following, we will begin by giving an overview of the origins of this active pedagogy. We will then outline its basic principles as well as the classic approach to implement it. Finally, we will detail the most important advantages and limitations of its implementation.

2.1 History

PBL originated in 1918 with the emergence of Kilpatrick's research [6]. In [6], the author attributed great

importance to the processes of knowledge acquisition rather than to the content itself. He emphasized the need to develop useful concrete activities for learners to stimulate their problem-solving skills.

Later on, the philosopher and pedagogue Dewey built on the work of Kilpatrick and initiated the learning by doing approach. He considered that we learn best by doing. He recognized that learners have an innate and natural desire to learn and that teachers must find concrete ways to satisfy this need [7].

2.2 PBL Principles

The PBL approach focuses on the active engagement of learners, one of the four pillars of learning, as it fosters curiosity, autonomy, and creativity [8].

With PBL, learners will no longer be led to retain passively the knowledge transmitted by the trainer or to memorize information, but rather they will be led to actively use the knowledge gathered in order to carry out projects or to solve problems while collaborating within a team. This approach is based on 4 fundamental principles [9]; namely:

- **Active construction of knowledge:** Learning occurs through the active construction of new knowledge from the learner's previous experiences and

interactions with the world around them. The project pedagogy is based on socio-constructivist learning theories, where students actively construct new knowledge through participation in a real-world project by seeking to solve a concrete problem and develop an artifact [10].

- **Contextualized learning:** PBL places the learner in an authentic situation and in a real-world context. This allows them to apply theoretical knowledge in real situations. Thus, students understand the purpose of what they 're learning and are able to memorize new knowledge.

- **Social interaction:** PBL is based on social interactions between students, the teacher and external partners. The sharing of ideas that takes place between these actors, the debate between peers, and the negotiation that takes place to reach decisions are all factors that enrich the learners and develop their social skills [11].

- **Cognitive engagement of learners:** The project leads learners to ask the right questions and encourages them to look for solutions [9]. The project itself is not as important as the process that led to it, i.e the series of actions carried out by the learners to achieve it. It is therefore a question of reaching the highest cognitive level of Bloom's taxonomy

represented by the verb "to create" at the top, *"The objective of project-based pedagogy is to equip learners with high level knowledge that promotes the intelligibility of reality"* [12].

2.3 The classic approach of PBL application

The classic approach to implementing PBL can be summarized in the following steps:

Phase 1 - Preparation and launch of the project: During this first phase, the teacher formulates the learning objectives and pedagogical intentions, prepares and presents the project and the rules to be followed, plans the process, forms teams of four to five people and split the roles of each member in the project [7], [10].

Phase 2 - Project implementation: Once the teams have been formed, the learners at this level take action: they plan their tasks and carry out their research. They meet regularly with their teacher to validate their research, reflect on their work, and discuss possible solutions. At the end of this phase, the teams must produce a concrete final product and write a report on their accomplished project [7], [10].

Phase 3 - Presentation and evaluation: In this phase, learners must present their completed product, demonstrating that

they have successfully acquired the necessary knowledge. The evaluation can be collective or individual and is not limited to judging the final result and the degree of achievement of the objectives (formal evaluation), but also focuses on the overall approach and progress of the project, as well as the level of contribution and collaboration in the project (individual evaluation) [7], [10].

Phase 4 - Project dissemination: During this last phase, the project is presented in class and publicly disseminated with the presence of external guests, teachers, and students from other classes. This phase can be conducted in tandem with the previous phase or separately [7].

2.1 The benefits of PBL

This approach is learner-centered and has many benefits for the student:

- It fosters motivation and a real commitment to the required work : the accomplishment of the final project is reached through small successes that allow the learner to progress and continue his work with interest, which can also increase the pleasure of learning and self-confidence [7].
- It develops problem-solving skills : during the project implementation, the learner may face several difficulties, and therefore he is led to overcome them and

make the right decisions to succeed [7], [10].

- It promotes learners' responsibility and helps them become autonomous: in this pedagogical formula, the learner assumes full responsibility for his success or failure [10].

- It promotes sustainable and in-depth learning that mobilizes long-term memory, rather than superficial knowledge, because learners practice what they are learning.

- It develops innovative and creative skills because this approach does not limit the learners' thoughts and ideas and offers them a greater degree of freedom compared to traditional methods [10].

- It increases the learners' communication and collaboration skills as they work in a team and are asked to manage their interactions with their peers and share their ideas and suggestions with them.

2.2 Limitations and hardships of PBL implementation

Despite the benefits of this approach, there are some limitations and difficulties that may affect its application and the success of the project. These limitations are as follows:

- The commitment of the learners for the accomplishment of the different

tasks of their projects requires a great investment of time which is not always obvious to ensure given the workload they have in other subjects [7].

- Inappropriate planning of the project and the lack of follow-up and support from the teacher can lead to learner's demotivation.

- The likelihood of divergent opinions among team members can create situations of conflict and disagreement within the group [10].

- The risk of confusing the purpose of learning since the learner is developing several skills at the same time. They may focus on the final product and disregard the steps and process to achieve it [7].

- Teachers face difficulties related to timing and instructional coordination. When implementing PBL, teachers must organize their material content and their schedules. This can be extremely time consuming and difficult to do [7], [14], [15].

- Teachers may find it difficult to evaluate individual members' contributions because some learners are more involved than others. Ensuring that everyone is contributing equally to the project becomes a challenge for the teacher [15], [16].

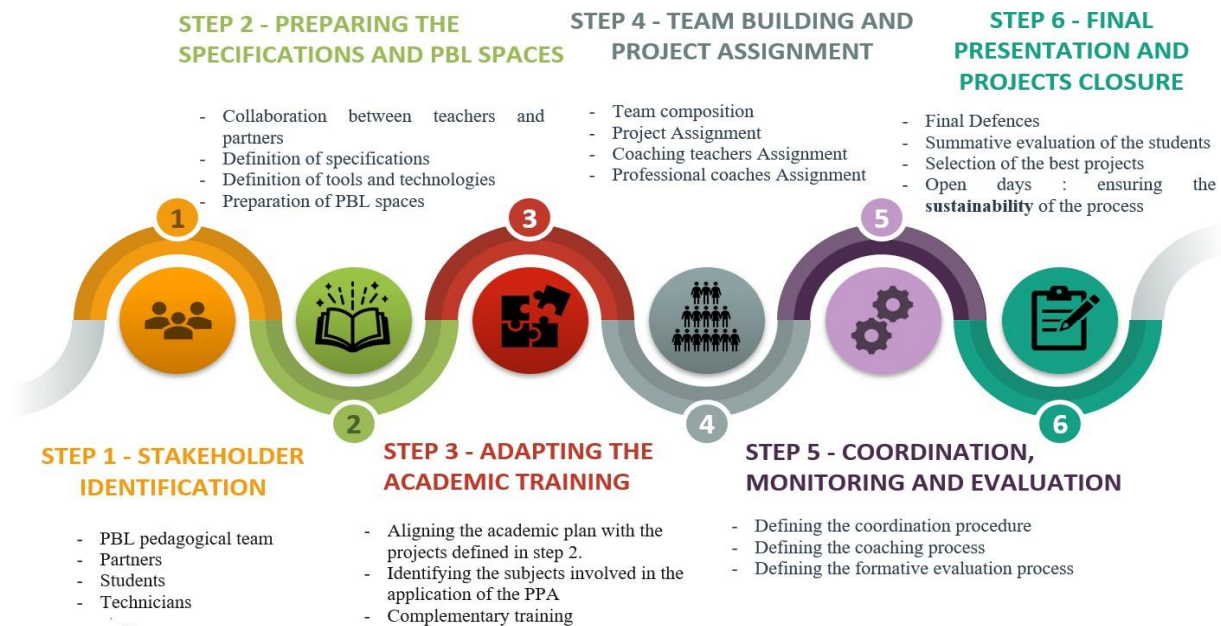
The new approach described in this article provides possible solutions that could overcome certain limitations related to PBL implementation, particularly, what is related to organization, planning, coordination, and communication between the various stakeholders, the monitoring and supervision of students, and the evaluation of the final completed work. The combination of our approach with the agile project management methodology Scrum [17] could also bring concrete solutions regarding the organization of work, the assignment of tasks in teams, time management and the improvement of students' motivation. Additionally, our approach aims to promote the employability of students by allowing them to carry out projects proposed by experts from the professional world.

3. *Our new approach*

In order to promote the professionalization of students and to allow them to establish direct contact

with the professional world, it would be interesting to involve companies, experts or socio-economic partners (professionals, government agencies, associations, etc...) throughout the PBL application. Our new approach allows us to enrich the classical experience of the PBL implementation and to improve the way we run it. Indeed, the involvement of professionals throughout the PBL implementation establishes direct contact with companies and strengthens cooperation with the professional world. The curriculum will thus be aligned with the needs of the job market, which will promote the employability of students at the end of their training. In order to succeed in this approach, teachers will have to be responsible for finding professional partners who are willing to collaborate with them. It is important to explain to future partners that their participation will save them money and time in the medium and long term, as they will be able to select the students to be hired, train them according to their needs, and consequently have new recruits who will be productive immediately after their academic training.

Fig. 1 Overview of the steps in our new approach



Our approach is based on the involvement of companies during the definition phase of the specifications of the PBL projects and during the identification of the technologies and tools to be used for the accomplishment of these projects. Professionals will be able to participate in the selection of subjects which theoretical knowledge will be used in the PBL projects. They can also, depending on their availability, participate in collaboration with the teachers in the follow-up and supervision of the students, attend the final evaluation of the work and select the best achievements. We recommend combining our approach with the use of the Scrum agile methodology which provides the basic building blocks necessary to ensure and strengthen cooperation between the various

stakeholders and within the students' teams. Moreover, Scrum helps them achieve their goals more efficiently by providing solutions for managing group work, distributing tasks, monitoring progress, organizing meetings, etc...

Throughout our approach we will indicate, whenever possible, the artifacts, roles and meetings that can be used based on the Scrum methodology. Note that the use of this methodology is recommended especially for projects where the business needs are not clearly identified at the outset. For small projects, with a short timeframe or with clear business needs identified at the beginning, we recommend the use of a classic project management methodology. It is noteworthy that the approach we are proposing is the result of an iterative

process of implementation, evaluation and adjustment that has lasted five years. Each year, we have taken into account student feedback and the assessment of what has not worked well to improve and adjust our approach. In the following section, we will begin by presenting an overview of the process to be adopted to implement our new approach. Then, we will outline the different actors who must participate in this process. Then, we will explain the method to be followed to prepare the project specifications and the rooms for the accomplishment of the PBL projects. Then we will highlight the importance of aligning academic training with the proposed projects. We will also detail the procedure for assigning projects to students and provide a method for coordination, monitoring and evaluation. Finally, we will describe the different steps to be considered in order to finalize these projects.

3.1 Overview of our approach

To facilitate the implementation of our new approach, we adopted a process divided into six steps, as shown in Fig. 1.

To apply our approach, we first need to start with identifying the different actors involved in the PBL implementation. Then, we need to focus on the steps related to the preparation of the project's specifications and the PBL spaces. At the

end of this second stage, it is important to adapt the academic training to the proposed projects. Then, the teams must be formed, and the projects must be assigned. The next step is dedicated to the coordination, follow-up and evaluation of the work done by the students. Finally, the last stage is dedicated to the final presentations and the closure of the projects.

In the following sections, we will describe these different stages in an exhaustive way.

3.2 Step 1- Stakeholder Identification

Before embarking on the experiment of applying PBL, a team must be formed to implement our new approach. On this basis, different actors will be involved, namely:

- The PBL pedagogical team: this team is made up of the teachers who are in charge of teaching the subjects which theoretical knowledge will be used in the PBL projects.
- The pedagogical coordinator: this is a single teacher who will be in charge of ensuring and supervising the pedagogical synchronization between the different subjects involved, in order to use the theoretical knowledge at the right time. He will also be in charge of coordinating between the different participants.

- Coaching teachers: these are the teachers who are responsible for monitoring and supervising the student teams throughout the PBL projects.

- Project tutor teachers: these are the teachers who will define the project specifications. These teachers must collaborate in advance with their partner company counterparts to define the first proposals for the project specifications. With Scrum, the tutor teachers play the role of the Product Owner, as they represent a unique counterpart between the client (which are the partner companies in our case) and the Scrum team represented by the team of students in charge of the project.

- Student Teams: A team of 4-5 students is assigned for each project. Indeed, the studies recommend a number between four and five students per team. A small team will have too little interaction and in contrast, a large team will have communication and organizational problems [7], [10]. With Scrum, each student team represents the Scrum team. A different team leader will be designated for each project phase and will play the role of the Scrum Master. The latter is responsible for, among other things, dispatching tasks (identification of tasks, assignment, negotiation of deadlines), integrating the results of the work, presenting the work done on behalf of his

team, discussing possible forms of collaboration with the other teams, etc...

- Technicians: they are in charge of preparing and maintaining the laboratories where the projects will be carried out. They can intervene in case of problems. It is important to note that specific training should be provided for these technicians, if

necessary, so that they can successfully maintain the equipment required for the projects.

- An academic training center: to successfully implement our approach, we need a partner or an academic training center that could offer additional training to teachers, students, technicians in charge of maintaining the equipment in the PBL spaces and to any other person involved in the PBL implementation. These trainings should be aligned with the different goals of the projects and be complementary to the traditional curriculum in order to fulfill the imminent needs of the projects' requirements proposed by the partners.

- Partner companies: Ideally, there should be one representative from each company for each project. This representative will be responsible, at the beginning, for defining the specifications of the projects with the tutor teachers. He will then

participate, as much as possible, in the follow-up and supervision of the students by attending the most important meetings throughout the project, in order to validate the work done. At the end, the company's representative could attend the final project presentation. Note that other experts from the partner companies can act as trainers to provide additional training (for students and/or teachers) or to teach specific subjects that are aligned with the goals of the projects proposed by their companies.

3.3 Step 2 - Preparing the specifications and PBL spaces

The specifications of the projects are prepared in advance by the tutor teachers in collaboration with the representatives of the partner companies. A specification could be proposed by one or more tutor teachers who commit to collaborate with the company representatives in order to gather the business requirements of the projects they want to propose and identify the technologies and tools to be used. The collected needs will be the subject of a first version of a specification that will allow to specify and define initially the objectives and the purpose of each proposed project.

During this stage, the tutor teachers must ensure that they define specifications with functional requirements that have equal

complexity between all projects. This ensures maximum fairness between the student teams. It should be noted that the business needs identified in the specifications can be adapted later, by the teacher coaches, according to the number of students in each team.

It would also be interesting to plan, before the start of the project, a visit to the companies for the student teams so they can better understand the problem, to collect additional needs and to refine the initial version of the specifications under the recommendations of their counterpart at the company level. This visit will be an important opportunity for the students to establish a first contact with the partner company.

After the definition of specifications, it is also necessary to think about the preparation of PBL rooms in advance together with the technicians. The PBL spaces are workrooms specially equipped for the accomplishment of the projects. They must have round tables to facilitate communication between the teams, the tutor teachers, the guests and all the actors who may intervene in the context of the PBL projects. In these rooms, there should be a dedicated space for each team with a Kanban board for the organization of work and the distribution of tasks. With Scrum, the Kanban board is called the Scrum scoreboard. In PBL rooms,

specific materials and equipment for each team should also be prepared according to PBL projects.

3.4 Step 3 - Adapting the academic curriculum

In order for students to successfully complete their projects, the academic coordinator must work with the PBL team, prior to the launch of the projects. This aims to adapt and align the content of the academic training with the objectives of the proposed projects. This should include, where possible, the following:

- The selection of subjects involved in the PBL projects which theoretical background will be used in the implementation of these projects.
- The definition of new subjects (if possible) that complement the study plan with content aligned with the objectives of the PBL projects. These subjects can be handled by experts from companies that have already proposed projects.
- The definition of a complementary training program for teachers and/or students (workshop, certification, accelerated training, or other...) is possible in order to deal with the changes and the imminent needs of the specifications proposed by the companies. These trainings can be provided by the academic training center, by distance

learning platforms or by experts from partner companies.

After identifying the subjects involved and the additional training required, the pedagogical coordinator, in collaboration with the PBL team teachers, prepares an initial coordination schedule, week by week. This schedule includes the courses and workshops to be taught each week and should be respected as much as possible by the teachers of the PBL team. This document is very useful because it allows students to use the theoretical and practical knowledge in time in the context of their PBL projects. It ensures pedagogical coordination and synchronization between the modules taught and the training to be completed.

3.5 Step 4 - Team building and project assignment

Before the start of the projects, the pedagogical coordinator, or the members of the PBL team will proceed with the formation of the student teams. We recommend an imposed composition for the teams in order to ensure equity between them. Indeed, each team should include students of good, average and/or fair level. In order to do this, before proceeding with the composition of the teams, the students of each class should be divided into three groups of different levels based on their averages (the

general average of the previous semester, or of the previous academic year). The gender of the students should also be taken into consideration during the composition in order to have balanced teams, composed of girls and boys at the same time. The composition of the teams will be announced to the students during the first PBL project kick-off meeting. During this meeting, the tutor teachers will present the PBL projects to the students. The presence of company representatives would be desirable during this kick-off session. The teams choose their projects according to their preferences. In case of conflicts, a draw is made.

3.6 Step 5 - Coordination, monitoring and evaluation

Throughout the different phases of the PBL projects, the pedagogical coordinator will have to follow the good progress and the good coordination with all the participants. He will organize weekly meetings with the PBL team and the teacher-coaches in order to monitor and update the progress of the different modules. The meetings organized allow, among other things, to verify the synchronization between the teachers of the PBL team and to identify the problems and difficulties encountered.

To ensure the follow-up of the work done by the students, each PBL project is divided into several phases. Based on Scrum, each phase is called Sprint. It is a short iteration for the realization of a part of the final project. Each phase lasts on average three weeks. Note that this duration could be adjusted according to the progress of the students and/or the occurrence of unforeseen events. The definition of the work required during each phase takes place during a meeting of the teacher-coach, the teacher-tutor and the team of students in charge of the project. With Scrum, this meeting is called the Sprint Planning Meeting. Two important Scrum artifacts are used to identify the work to be done during this meeting: the Product Backlog (which contains the features of the entire project in the form of user stories), and the Sprint Backlog (which contains the features to be completed for the current Sprint). Note that the Sprint Backlog contains the tasks to be done with deadlines, assignments, and estimates. The progress graph is used during each Sprint to know if the team is ahead or behind the deadline.

During each phase, a tracking score and a validation score will be given by the teacher coach to each student and each team week by week. At the end of each phase, students are asked to complete a portion of the total work required. With

Scrum, this part of the work is called the deliverable. For the validation of the work done during each phase, the presence of the professional team member is desirable in order to approve the work done, to ask for modifications or corrections and to give the agreement to move on to the next phase. With Scrum, this validation meeting is called the Sprint review meeting. It takes place in the presence of the Product Owner, the customer, and the members of the Scrum team. Another meeting is planned with Scrum, it is the Sprint retrospective meeting which is intended only for the team members and aims to reinforce the team spirit. During this meeting, the team members try to identify the positive and negative points of the previous sprint while suggesting possible improvements for the next sprint.

To ensure the daily follow-up and evaluation of each student and each team, we have defined a document called "Tracking Book" that will be used by the teacher coaches to follow the progress of their teams (See Appendix B). The logbook is a document that is very useful because it allows the students' work to be monitored and evaluated objectively and on a daily basis, based on a set of criteria. This document includes evaluation sheets, week by week according to the work requested. Each sheet is composed of four sections, namely:

Section 1 - Evaluation of the collective work: The evaluation of the collective work is based on a set of criteria which include the respect of the planning, the respect of the instructions, the preparation of the team meetings, the quality of the work, the progress made, the distribution of the tasks and the taking into account of the remarks of the teacher coach.

Section 2 - Evaluation of individual work: The evaluation of individual work is based on criteria that include the presentation of the work, the motivation of the student, the individual work submitted, the quality of the work submitted, the response to questions, the attendance (number of absences) and the role of the student (project leader or simple team member).

Section 3 - Weekly checklist: this list includes items that allow the teacher coach to check the work due, the work to be done during the session and the work to be done for the next session.

Section 4 - Notes: this section contains remarks that could be noted about the team's work or about the individual work of each student.

Note that the logbook should be a shared document that can be consulted by the different stakeholders.

3.7 Step 6 - Final presentation and projects closure

The final evaluation will take place in a similar way to the final projects. Nevertheless, the jury will be composed of the project tutor, the team coach, the company representative, a member of the PBL team and, possibly, a guest teacher from another department of the institution in order to stimulate intra-departmental communication. During this defense, each team presents the work done with a digital presentation support and a demonstration of the project carried out. The demonstration will be followed by a discussion with the members of the jury. The defense is closed by a deliberation session, during which the jury gives a final grade to the team and an individual grade to each student.

At the end of the projects, and in order to ensure the sustainability of this new experience, it would be interesting to organize an open day that would allow students to present the work done in the context of their PBL projects in booths. This event is of great importance because it aims mainly at ensuring the sustainability of the PBL projects. Other experts from the professional world will be invited and may be attracted by the quality of the projects carried out by the students. They will likely be more willing

to participate in the application of the PBL during the following year.

This event is also an opportunity to establish a "Student - Company" contact, with possible hiring possibilities, or to obtain internship offers and a "Teacher - Company" contact in order to find new partners wishing to participate in the future in the implementation of this experience.

4. Case study : Application of PBL at ISET Beja

The case study presented in this section is based on the study plan of the Information Systems Development (ISD) course of the computer science license delivered by the Higher Institute of Technological Studies in Tunisia.

The application of PBL has been initiated gradually at ISET Beja since 2017 based on the experience made in ESPRIT. In the old study plan, we have integrated an optional subject, named "Integration and Development Projects", intended for the ISD course during the 5th semester, in order to apply the PBL method. In the context of this subject, the students had to develop a web application with Java EE technologies while using the Scrum agile methodology. We have adapted the content of different subjects that allow students to successfully complete their

projects. In 2018, the new study plan for ISETs proposed to include a new subject named "Integration Projects" to the ISD pathway in semesters 4 and 5. To this end, we have continued to apply the PBL active pedagogy for the implementation of the integration projects while targeting the new subjects included in the new study plan.

In what follows, we will first be presenting our own conception of the organization and objectives to be achieved in the "Integration Projects" module. This module represents the core subject in which we have initiated the application of our new PBL-based approach. Then, we will present the different steps followed for the application of PBL during the academic year 2021-2022 at ISET Beja. Note that we have been inspired by the steps of the new approach that was developed in the previous section to successfully apply PBL. Finally, we will close this section with perspectives and possible improvements to enrich this experience.

4.1 Presenting the "Integration Projects" module

The "Integration Project" module is the central subject in which the monitoring and supervision of the projects carried out in the context of PBL application takes place on a daily basis. It is a module with

a time load of 22 hours with a slot of 1.5 hours per week, which could be spread over a semester of 14 weeks. The shared objective of integration projects is to successfully develop a constellation of integrated applications (web and mobile) while using the agile Scrum methodology. At the end of this project, the student will then be able to:

- Develop a web application with the Angular framework [18] and REST web services [19], [20].
- Develop a mobile application with Android [21].
- Integrate his work via a collaborative work platform (with the exploitation of Git and Bitbucket [22], [23]).
- Apply the Scrum agile methodology for project management.
- Write a report in French and improve communication skills.
- Coordinate a team, agree, manage conflicts, and deliver a work plan.

4.2 Step 1 - Identification of the actors

During this step we begin by forming a team of teachers having the different actors' roles defined in our approach (see Section III.B. Step 1 - Identification of actors). Note that the same teacher can

have several roles: for example, he can be a teacher coach and a teacher tutor at the same time. The professional partners identified are the companies that offered internships for end-of-studies projects to the students of ISET Beja, belonging to the ISD specialization, of the previous cohorts.

The 4C center of ISET Beja is in charge of proposing complementary training to the students and the teachers in case of need. In addition to the training offered by the 4C center, the PBL team members and coaches used accounts on online training platforms such as Coursera and Bright Coding to consolidate their technical skills.

4.3 Step 2 - Preparing the specifications and PBL spaces

The application of our approach is not possible without a certain maturity regarding the application of the steps related to this approach. To this end, we have proposed to progressively involve professional partners. For this first experiment, the teachers who tutor the projects began by listing the partner companies that hosted the students during their PFE internships, and they drew inspiration from the proposed topics and the technologies used for the drafting of the PBL project specifications. The tutor teachers also analyzed the catalogs of

PFE subjects, proposed by other companies, on the professional network LinkedIn and on job sites (Examples : List of PFE Book 2022, Example of a PFE BOOK, Example of a PFE internship offer). Through this analysis, they were able to identify the cutting-edge technologies most in demand by the companies that host students. The technologies identified are Spring Boot, Angular, React (TypeScript), Git, NodeJS, Express JS, IONIC, Flutter, Django (Python), Laravel and Next JS.

These two steps allowed us to identify future partners to be contacted and solicited for our new approach and allowed us to propose specifications that are aligned with the current functional and technical needs of companies. When writing the specifications, the tutor teachers detailed the main functionalities of the PBL projects to be carried out. These projects all have the same objective, which is to implement a web application and a mobile application while using the Scrum agile methodology. It is important to note that the tutors take great care to define the specifications with the same degree of complexity to ensure fairness and impartiality between all teams. For the PBL spaces, the PBL team members recommended keeping each class in the same practical room assigned to the subjects involved in PBL projects. This

makes it possible to provide students with computers configured with the necessary work environment for the accomplishment of their projects and workshops. In these rooms, a dedicated space for the display of a Kanban-type board has been provided for each team. The Kanban board contains post-it notes of different colors allowing the organization of the work and the distribution of tasks, during each Sprint, following the Scrum agile methodology.

4.4 Step 3 - Adapting the academic curriculum

Based on the advanced technologies identified during the previous step, the educational coordinator and the members of the PBL team identify the modules which theoretical knowledge will be used throughout the implementation of PBL projects. In addition, other modules have been added in the context of the optional subjects present in the ISET study plan. It should be noted that the pedagogical coordinator, with the help of the PBL team, has been responsible for preparing a coordination schedule between the most important modules. This schedule is designed to ensure synchronization of progress between the teachers of the PBL team. This will allow the student to use the theoretical knowledge in time for the PBL project. The main objectives of the PBL projects are the development of

REST web services, the development of a web application with Angular and the development of a mobile application with Android. In this context, the pedagogical content of the modules involved needs to be adapted in order to align the academic training with the planning and objectives of the PBL project sprints. Based on the syllabus of the ISD course in semester 5, the modules mainly involved in the PBL projects are adapted as follows:

- « Integration project »: This is the central module in which the monitoring, supervision, and validation of the different phases of PBL projects takes place.

- « Service Oriented Architectures » and « SOA Workshop »: In these two modules, the student will learn, among other things, how to develop REST web services and consume them with an Angular client. The PBL teacher in charge of teaching these two modules makes sure to integrate the parts related to REST web services before the start of Sprint 2 in order to allow the students to implement the first part of the web application.

- « Mobile Development » and « Mobile Development Workshop »: In these two modules, the student will learn mobile development using Android. The teacher of the PBL team in charge of teaching these two modules makes sure that the

students succeed in mastering the theoretical and practical knowledge necessary for the accomplishment of the integration projects 'mobile application before the start of Sprint 4 dedicated to it.

- « Object design methodologies »: In this module the student will learn, among other things, to use the agile methodology Scrum. The teacher in charge of this module starts by introducing and explaining the principles of the Scrum methodology in order to allow the students to utilize this methodology in the context of their integration projects.

- « Technology watch »: This is an optional subject that allows students to learn, among other things, how to use the Bitbucket collaborative work platform, to integrate their work with GIT and to manage dependencies with Maven. The teacher in charge of this module starts from the first sessions to guide the students through the different steps to ensure collaborative work and versioning management with Git on the Bitbucket platform.

- « Spring Boot » and « Spring Boot Workshop »: This is an optional unit that includes two modules allowing the student to develop microservices with the Spring Boot framework while based on the REST architecture style. The students could have a second alternative to

develop the backend part of the project during the sprint 1. The content of these two modules is proposed based on the requirements of the PFEs of the two previous years.

- « Communication techniques »: In this module, students should learn how to write reports, prepare digital slides, master public speaking and improve their communication skills.

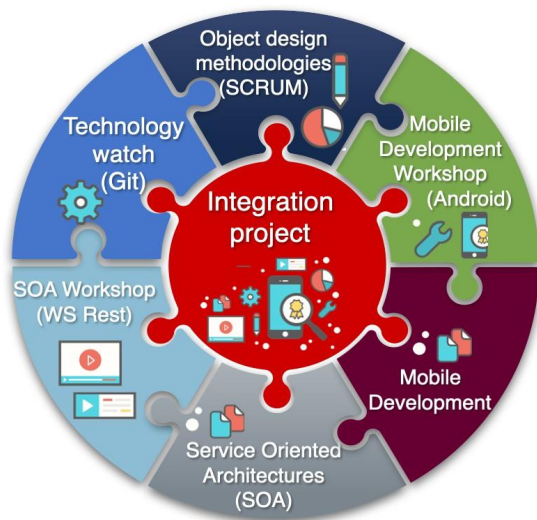
Fig. 3 gives an overview of the most important modules that have been used for the accomplishment of PBL projects during the academic year 2021-2022 at ISET Beja.

In order to achieve the objectives of the integration projects, the PBL team underwent specific training to consolidate the technical skills taught in the modules involved in the PBL projects. The PBL team members have followed the following trainings: The "Version control with Git" training on Coursera, Angular training on Bright Coding and Spring Boot training on Bright Coding.

The 4C Training Center has also participated in improving new technology 'skills by organizing: a Spring Boot training (for the benefit of teachers and students of the Computer Science department in ISET Béja , which was led by a member of the PBL team) and an

Angular workshop for the benefit of the students of the Computer Science department of ISET Beja

Fig. 2. Overview of the most important subjects involved in PBL application



4.5 Step 4 - Team building and project assignment

The teams' formation and the assignment of the projects take place during the first workshop of the module "Integration projects". The first session will be characterized by the presence of all the tutor teachers who will be responsible for presenting the PBL projects to the students. It is important to remember that the teacher who will be in charge of the sessions of the "Integration projects" module will play the role of the teacher coach. Remember also that the tutor teachers will play the role of the Product Owner in the context of the application of the Scrum methodology. During this first

session, the teacher-coach will announce the composition of the teams predefined by the members of the PBL team. Remember that the teams are composed of 4 to 5 students. Then, the students are asked to reorganize the room according to the announced composition: each team must sit around a table and choose a work space in the PBL room.

Each team is also asked to choose a representative from Sprint 0 (the Scrum Master) and a team name that represents them. This promotes the spirit of collaborative work and helps to stimulate cohesion among the group members. After the teams have been formed, the tutor teachers present the projects which aim to develop a web application and a mobile application for different themes (online library, platform for translators, bartering platform, online flat sharing platform, etc.). After 15 minutes of reflection and discussion, the Scrum Master of each team gives the name of the selected project to the teacher coach. In case of conflict between one or more teams, a first round of draw is made. Teams that were not lucky enough to get their initial choice move on to the second round and again select another project from the remaining projects.

4.6 Step 5 - Coordination, monitoring and evaluation

During this stage, the pedagogical coordinator is in charge of organizing regular meetings between the different stakeholders while referring to the pre-established coordination schedule. These meetings ensure coordination and synchronization between the teachers and give an overall visibility of the progress of the PBL projects, and the subjects involved.

In what follows, we provide an overview of the progress of the various workshops in the "Integration Project" module. Note that after Workshop 1, each session could be either a follow-up session or a validation session for a specific workshop. During the follow-up sessions, the teacher-coach is in charge of monitoring the progress of the teams by referring to the Sprint Backlog of the current project phase and the Scrum board. During each session, the teams must update their Kanban board and must prepare the progress chart of the current sprint. These two artifacts are of great importance because they allow students to break down the tasks performed in teams and allow them to know if they are ahead or behind schedule. During the validation sessions, each team organizes the review meetings and the retrospective meetings of the Sprint in the presence of the teacher coach and the teacher tutor. They validate the work done on the current

sprint and launch the next sprint. During the validation sessions, the teams update and prepare the new Scrum artifacts (Product Backlog and Sprint Backlog).

It is important to note that during each session, the follow-up and evaluation of the work are done by means of a follow-up notebook designed for each team. This notebook is used by the teacher-coach to grade, take remarks, check the work done, etc... The work requested during each phase should be submitted by the Scrum master of each team on the UVT Moodle platform (Link to the course "Integration projects"). This platform plays a critical role in the successful application of our approach because it offers, among other things, an efficient means of communication between students, teams and the various stakeholders (exchange forums, instant messaging, asynchronous messages, planning of online coaching sessions, sharing of resources, etc.). In addition, the collaborative environment offered by the UVT platform for the entire class and for each team has created a thriving, inclusive community that has given students a sense of belonging. This plays an important role in motivating and engaging students throughout the completion of their projects.

4.7 Step 6 - Final presentation and projects closure

At the end of their project, each team of students will have to validate their work through presentations similar to the ones they will have during their final projects. They are required to prepare and submit a full report on the UVT platform, one week before the scheduled date of the defense. They must also prepare a presentation that summarizes the work accomplished throughout their projects.

The defense takes place in the presence of the teacher coach, the teacher tutor, a guest teacher, and a member of the PBL team. The duration of the defense is 45 minutes, divided approximately as follows : 20 minutes for PowerPoint presentation, 10 minutes for demonstration of the application and 15 minutes for discussion. At the end of the presentations, all the members of the jury meet and select the best project for each class. A certificate of recognition and a symbolic award are provided to the winning students.

5. Evaluation of PBL application at ISET Beja

To evaluate the application of PBL within ISET Beja and more particularly at the level of the integration project module, two studies were conducted: a qualitative study and a quantitative study.

The qualitative study consisted of an in-depth interview with 10 students (5 in PFE and 5 alumni) in order to understand the impact of integration projects on their technical and personal skills. This study aimed to identify the aspects of the PBL perceived positively by the students on which we must capitalize, and the aspects perceived negatively by them and that we must question to improve our approach.

The majority of the interviewees mentioned the positive impact of the integration projects on their technical skills and teamwork. The Scrum agile method helped them to organize their work and improve communication within the group, which reduced conflicts between members of the same team. For them, these projects are a good preparation for PFEs and have contributed to the improvement of their ability to learn new technologies or programming languages. This last point is very important for their future professional career characterized by a rapid evolution of the technologies used. These in-depth interviews helped us to formulate the hypotheses to be validated by the quantitative study:

- **Hypothesis 1:** the integration projects prepared the students well for PFEs.
- **Hypothesis 2:** The quality of the PFEs has improved significantly since the

application of the PBL in the integration projects.

- **Hypothesis 3:** Students are better prepared for the job market.

The quantitative study, to this effect, was conducted with the students of the last 5 graduating classes and the teachers who supervise the PFEs of the ISD specialization. Two questionnaires were prepared using Google Forms and shared via email and social networks. The response rates were quite satisfactory: 60% for teachers and 30% for students. Regarding the teacher survey, 67% of the teachers underlined a noticeable improvement in the quality of the PFEs carried out by the students at ISET Beja since the year 2017 which corresponds to the year of starting the application of the PBL at the level of the integration project module. 67% of teachers also said that the integration projects have contributed over the past 5 years to a large extent to the preparation of students to PFEs and have noted a significant improvement in the technical skills of students supervised. In addition, the teachers noted that the technologies used by the students are cutting-edge and increasingly in demand on the job market.

The survey conducted among the students revealed the following points: 70% of the respondents believe that the integration

projects have improved not only their technical skills but also their social skills (teamwork, self-confidence, public speaking). Indeed, the list of technologies used in the framework of the PFEs over the last 5 years shows that 70% of the students have worked with Angular, 30% with Spring Boot, 27% with NodeJS and 22% with REST web services. This represents a qualitative leap in the use of cutting-edge technologies and the preparation of students for the job market. This is especially true since 100% of the respondents applied the Scrum agile methodology, which is used and requested in professional life, in the context of their PFEs. All this had a positive impact on the students' confidence in their future as 87% of the respondents felt well prepared for professional life. Respondents to the questionnaire also made suggestions for improvement for the "Integration Project" module: 85% of them insisted on the importance of integrating this module before semester 5 and more specifically during semester 4 and of allocating more sessions per week to it. The majority also stressed the importance of having complementary technical training in parallel with the realization of the projects, of giving students the chance to choose the technologies to be used and to give them more guidance, especially in validating the codes. Other respondents

suggested deploying the applications on Microsoft Azure and having a competition between ISETs for the best integration project nationwide. The results of the quantitative study validate our research hypotheses. The integration projects are a good preparation for the students for the PFEs which have seen a significant improvement in terms of technologies used. The PBL contributes not only to the students' technical skills but also to their soft skills, which improves their employability.

6. Conclusion

Initiated since 2017 at ISET Beja, the PBL has contributed to a large extent to equip students with the technical and transversal skills necessary for their employability. And although the principles of application of PBL appear at first glance simple, its implementation in practice can run into difficulties, which in some cases can discourage teachers who seek to apply it or prevent them from achieving the expected results of this approach.

What we have proposed in this article is a practical approach to the application of PBL that could serve as a guide for teachers who wish to implement this approach in their institutions. The latter can draw inspiration from our approach and contextualize it according to the

specificities of their disciplines and the constraints of their own context. Beyond a simple guide, we have proposed a toolbox for the successful implementation of PBL. Three essential factors contribute to the success of the approach we have proposed. First, the involvement of industry experts so that the projects are in line with the reality of the professional world. In this context, the PBL team at ISET Beja has requested the collaboration of several professionals for the realization of integration projects during the next academic year. The idea of the orientation of the application of PBL towards the professionalization of students was approved and strongly encouraged by several representatives of companies who volunteered to become our future partners in ISET Beja. Secondly, PBL must be applied in a perspective of decompartmentalization between the subjects. Thus, the student will be able to perceive the interrelations between the different subjects he is studying and will be able to understand their usefulness and how to integrate the different knowledge acquired in these courses through the projects carried out. Finally, the management of the university must ensure the necessary logistics for the application of PBL (equipment, layout of PBL rooms, training of PBL room technicians, etc.) in order to successfully apply this active pedagogy.

7. Bibliography List :

1. V. Dmitrovic, « par l'apprentissage par projets, nouveau fer de lance de l'innovation pédagogique ? Exploration du cas des Business Schools en France », p. 16, 2018.
2. A. Potter et K. Louati, « Learning English through project-based learning: The case of engineering education », in 2016 IEEE Global Engineering Education Conference (EDUCON), Abu Dhabi, United Arab Emirates, avr. 2016, p. 301-303. doi: 10.1109/EDUCON.2016.7474570.
3. L. Bettaieb, « Esprit PBL Case Study », in PBL in Engineering Education, A. Guerra, R. Ulseth, et A. Kolmos, Éd. Rotterdam: SensePublishers, 2017, p. 103-118. doi: 10.1007/978-94-6300-905-8_7.
4. S. Gharbi, H. Bellakhdar, et S. E. Mrabet, « Project based learning in business intelligence with intervention of companies », in 2015 IEEE Global Engineering Education Conference (EDUCON), Tallinn, Estonia, mars 2015, p. 384-387. doi: 10.1109/EDUCON.2015.7096001.
5. A. Belgasmi, R. Chalghoumi, J. D. Ngono Essimi, N. I. Rahmouni, N. Ajailia, et A. HAMROUNI, « Project based learning: Civil Engineering Student's feedback (case study) », Hammamet, Tunisia, juin 2019. Consulté le: 12 avril 2022. [En ligne]. Disponible sur: <https://hal.archives-ouvertes.fr/hal-02868926>
6. W. Kilpatrick, « The Project Method », Teach. Coll. Rec., vol. 19, no 4, p. 319-335, sept. 1918.
7. J. Proulx, L'apprentissage par projet. Sainte-Foy: Presses de l'Université du Québec, 2004.
8. E. Gaspar, « Les quatre piliers de l'apprentissage - Stanislas Dehaene », p. 8.
9. KRAJCIK, J. S., & BLUMENFELD, P. C. (2006). PROJECT-BASED LEARNING (PP. 317-34). NA
10. M.-A. Hinse, « L'apprentissage par projet pour favoriser le développement de compétences en périnatalité chez les étudiantes et les étudiants du programme de soins infirmiers au collégial », p. 176.
11. P. C. Blumenfeld, R. W. Marx, E. Soloway, et J. Krajcik, « Learning With Peers: From Small Group Cooperation to Collaborative Communities », Educ. Res., vol. 25, no 8, p. 37-39, nov. 1996, doi: 10.3102/0013189X025008037.
12. M. Boutet, « Expérience et projet : la pensée de Dewey traduite en action pédagogique », Phronesis, vol. 5, no 2, p. 23-34, déc. 2016, doi: 10.7202/1038137ar.
13. « Pyramide-taxo-bloom-1820 x 1024.jpeg (1820x1024) ». <https://widid.fr/wp-content/uploads/2020/05/Pyramide-taxo-bloom-1820x1024.jpg> (consulté le 12 avril 2022).
14. P. Guo, N. Saab, L. S. Post, et W. Admiraal, « A review of project-based learning in higher education: Student outcomes and measures », Int. J. Educ. Res., vol. 102, p. 101586, janv. 2020, doi: 10.1016/j.ijer.2020.101586.
15. T. Mckenna, A. Gibney, et M. G. Richardson, « BENEFITS AND LIMITATIONS OF ADOPTING PROJECT-BASED LEARNING (PBL) IN CIVIL ENGINEERING EDUCATION – A REVIEW », p. 10.
16. I. Gratchev et D.-S. Jeng, « Introducing a project-based assignment in a traditionally taught engineering course », Eur. J. Eng. Educ., vol. 43, no 5, p. 788-799, sept. 2018, doi: 10.1080/03043797.2018.1441264.
17. A. Jurado-Navas et R. Munoz-Luna, « Scrum Methodology in Higher Education: Innovation in Teaching, Learning and Assessment », Int. J. High. Educ., vol. 6, no 6, p. 1, nov. 2017, doi: 10.5430/ijhe.v6n6p1.
18. E. Saks, « JavaScript frameworks: Angular vs React vs Vue », p. 47.
19. H. Li, « RESTful Web service frameworks in Java », in 2011 IEEE International Conference on Signal Processing, Communications and Computing (ICSPCC), sept. 2011, p. 1-4. doi: 10.1109/ICSPCC.2011.6061739.
20. M. Masse, REST API Design Rulebook: Designing Consistent RESTful Web Service Interfaces. O'Reilly Media, Inc., 2011.
21. B. Speckmann et A. Review, « The Android mobile platform by ».
22. J. Lawrance, S. Jung, et C. Wiseman, « Git on the cloud in the classroom », in Proceeding of the 44th ACM technical symposium on Computer science education, New York, NY, USA, mars 2013, p. 639-644. doi: 10.1145/2445196.2445386.
23. J. Kelleher, « Employing git in the classroom », in 2014 World Congress on Computer Applications and Information Systems (WCCAIS), janv. 2014, p. 1-4. doi:10.1109/WCCAIS.2014.6916568.