Planning PBL in Computing Education

An Approach Based on a Collaborative Toolkit

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***Abstract*— This Innovate Practice Full Paper presents a case of use of the PBL Planner toolkit, a tool that assists collaborative teaching planning in the PBL approach, from preserving its principles. The PBL (Problem-Based Learning) methodology provides many advantages to those adopting it in the teaching-learning process. To this end, a good planning that guides the usage of the methodology towards the goals established by the teacher is fundamental, in order to prevent core aspects to be neglected. However, there is a lack of specific solutions to help teachers to plan their teaching. This is even more pronounced in the specific case of PBL. As a solution to this problem, this paper proposes a tool composed by a PBL Canvas and a set of cards, used to guide the teaching planning in PBL, called PBL Planner Toolkit. Initial results indicate a good acceptance of the tool, as well as evidence of its efficacy its adoption, elicited through the application of a survey that evaluated the usage of the PBL Planner Toolkit.**

Keywords*— *Canvas; Computing, Educational Planning; Problem-Based Learning; Toolkit.

I. INTRODUCTION

WITH the advance of Information and Communication Technologies (ICT), together with their widespread use in all sectors of the products and services market, the creation of Computing solutions is no longer a problem that demands only technical skills. In fact, it has become a multidisciplinary issue.

The need for multiple competences formation, with an emphasis on technical and soft skills, has given space to student-centered approaches, where students own their learning process, instead of traditional teaching approaches, that focus on content transmission. One approach that stands out in this category is Problem-Based Learning (PBL) [1],[2],[3]. There, the learning process is defined by the students, who, through research, study, planning, critical analysis and continuous reflection, search for solutions to problems related to the object of study. This is accomplished through teamwork conducted within a managed process. Problems to be solved are unstructured, ill-defined, and subjected to a large number of changes and definitions, as it is the case with the workplace.

PBL is being increasingly used in computing teaching. The study reported in [4] shows a growth in publications about PBL experiences in the last two decades, with results that favor competence development, make understanding and problem resolution easier, foster student participation in the classroom, enhance students' study time management, better preparing them for the work market. Reference curricula in the area, such as the "Computer Science Curricula" from ACM/IEEE [5], also consider the approach within their guiding principles, highlighting competences related to problem solving, project management, oral and written communication, besides technical contents recommendations.

Perceived benefits from the use of PBL, and their alignment with market demands are evident. However, implementing PBL is a task that demands great transformations. Educational objectives need to be aligned with well-defined goals. The problem needs to be aligned with the "Educational Objectives", to be relevant and complex enough to challenge students, to be real (and to have a real owner) and not to be a simulation or a teacher invention. In this light, the authenticity of the "learning environment" is fundamental. Traditional teaching classrooms, prepared for lectures, need to give place to group work environments, where groups can discuss problems, plan tasks and carry them out. New roles arise in this authentic learning environment: the technical tutor (called technical leader in the software industry) that supports teams, generally the technical tutor can be a professor or a monitor; the PBL tutor, which monitors the teaching-learning approach; the client, which proposes a real problem to be solved and monitors its solutions. Role and specific responsibilities need to be assigned to students, who now work continuously in teams. The content is considered to be a support to learning in real problem solving, and not the focus of learning. It is provided not only by books, but by various information sources, including videos, podcasts, content portals and learning communities. Real corporation documents become content objects, such as business process models, IT strategic plans and stakeholder mappings. In this scenario, to assess students based on the final product delivered or on a written exam is not enough. Other aspects need to be considered in the assessment, compatible with the work market, for example, the final product quality is as important as its building process.

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And the team interaction is as important as the planning of their project. These aspects need to be monitored formatively, not only by the teacher, but by all of those involved in the teaching-learning process, including the students and the client.

Few solutions are available for PBL planning. References such as [5], [6], [7] and [8] highlight the format of PBL curricula, and others such as [9], [10], [11] and [12] propose problem-solving models. However, the implementation of the approach, in its managed form, is not taken into consideration, identifying necessary elements and resources. This has a great impact on the application of PBL, be it on the lack of resources to maintain it, or on the weak adhesion of those involved, or yet in the lack of metrics to allow its monitoring and that demonstrate its effectiveness.

Hence, this paper proposes a model for planning the PBL approach in Computing education, called "PBL Planner Toolkit" (PBL Toolkit, in short), a toolkit based on a visual collaborative planning tool (a canvas-like board) supported by cards with instructions for filling it up. The cards were built based on the PBL application methodology for Computing teaching defined in [13], which proposes key manageable elements, and on the Project Management approach PM Canvas [14]. This paper presents the construction model and its main foundations, besides describing the model in general, discussing how it should be used. For usage and applicability demonstration purposes, a few reports of the application of PBL Toolkit are presented as case studies. Finally, the paper presents the main results obtained, points for improvement and next research steps.

II. THEORETICAL AND METHODOLOGICAL KEY REFERENCES

The Theoretical and methodological background that substantiate this research are presented in this section.

A. PBL Principles

The PBL methodology is based on principles [12]. In a research [16] performed from 4 key studies, 10 essential principles in PBL were defined, that are a guide to an effective approach. The 10 principles are:

1. All learning activities are anchored on a task or problem; 2. Learners should feel that they own the problem, and are responsible for their own learning; 3. The problem should be real; 4. The task and the learning environment should reflect the reality of the professional market; 5. Learners need to own the process and use them to work out the problem solution; 6. The learning environment should stimulate and at the same team challenge the learners' reasoning; 7. Learners should be encouraged to test their ideas against alternative views and contexts; 8. Learners should have the opportunity and support to reflect on the content learned and the learning process; 9. Learning is collaborative and multidirectional; 10. PBL is supported by the planning process and continuous monitoring.

B. Approaches to Implementing PBL

There are many experience reports regarding the implementation of PBL in courses in the Computer Science area. These reports are important and represent a search for a more general model. However, they illustrate that research in this area is more empirical and case-based and has hardly been conceptualized in more theoretical and model-oriented approaches.

There are researches that present models for implementation of the PBL method. Hung's [11] 3C3R model is a framework that emphasizes problem formulation aligned with educational objectives. The model name highlights central components related to C (content, context, connection); which are used to support R (researching, reasoning, reflecting) as processing components that tackle students' cognitive process and problem-solving skills. However, in the model nothing is mentioned regarding monitoring and management of the model and students' learning. Thus, even if the problem is well designed and effectively described, this is not a guarantee of the effectiveness of the teaching and learning process as a whole even if this is one of the factors that contributes to success.

Vidal [18] proposes a computer teaching planning tool in the PBL approach based on the backward design model called PBL-Tutor Canvas. The purpose of the tool is to support the teacher during the planning of his classes to comply with the PBL principles and processes. As the purpose of the lesson planning, the tool does not provide the support for the planning of disciplines together or for the entire curriculum of a course in which the PBL method is to be adopted.

Based on the PBL method and the Two Tracks Unified Process (2TUP) process or "y" software development process, the researcher Expósito [19] developed a learning methodology called yPBL, which is intended to be used in the context of software engineering courses, based on the construction of a real software system. Expósito defines yPBL as a mapping between the PBL method and the "y" process, through the roles and phases considered in the PBL method with the roles, iterations and phases considered in the "y" process. In the yPBL methodology, incremental and iterative phases are performed, and the specific communication channels are established through common documents within a real software project. However, this methodology can make the learning process, from the perspective of the PBL method, less flexible since it is structured exclusively for software development and because it does not have in its definitions the essential relations with the PBL principles that underlie the essence of the PBL method.

C. The xPBL Methodology

xPBL is a methodology for PBL planning in computing teaching [13]. It consists of 5 manageable elements: Problem, related to the problem definition used as study object and learning construction; Environment, related not only to the physical environment, but also to the systemic environment,

that encompasses technological support and team formation process; Human Capital, recommending essential roles for the approach, such as tutors (technical support and PBL monitoring) and real clients, besides the teacher and students playing the role of Software Industry professionals; Contents, defined as being every guide and learning support, provided by various information sources, besides the traditional books and papers; and last, but not least, Processes, focusing on assessment processes. A guideline was developed for each of these components, to support reflection on them and planning. In order to do so, the xPBL guidelines use the management technique 5W2H, that, through the questions "What?", "Why?", "Who?", "Where?", "When?", "How?" and "How much?" support the planning and management of each of their elements. The guidelines recommend the creation of artifacts or the application of models as the output result of the planning of each element.

Although the guidelines help PBL planning, the authors have observed, in their real PBL application cases, the need for an instrument that is easier to use, and that has more detailed information. The guidelines do not have examples, and more often than not, there were doubts about what to apply and how to apply it. Since PBL planning is essentially collaborative, minimally involving the teacher, tutors and course coordinator, we have chosen to investigate tools that supported planning and collaborative discussion, as well as a record of the planning that is quicker, visible and transparent to all involved.

D. The Project Management Approach PM Canvas

The Project Model Canvas, or PM Canvas, is a project and portfolio management methodology that uses good Project management practices together with neuroscience knowledge [14]. Finochio argues for agility in the construction of a Project Model Canvas and prioritizes the relations between the components that compose the tool. The PM Canvas makes visual planning easier, and with this methodology, simplifies communication, making a global project view possible. PM Canvas is composed by 13 fields: Justifications, SMART objectives (Specific - Measurable - Attainable - Realistic – Time Bound), Benefits, Product, Requirements, Stakeholders, Team, Constraints, Premises, Delivery Groups, Risks, Timeline and Costs.

The PM Canvas has been successfully applied in the collaborative planning of projects in various real cases [14]. Its features show that the approach may be used in many project contexts. However, for pedagogical planning, specific areas related to the teaching and learning approach need to be considered, like educational objectives, goals and indicators of pedagogical success, evaluative processes, among others.

E. Research Method

We have used the Design Science Research Method (DSR) [15] to build the PBL Planner toolkit, since the method is recommended for research works that aim at developing artifacts of descriptive solutions using a real or simulated environment. The proposal is to allow artifact elaboration or assessment, modification of activities or situations so that they may attain an expected goal based on idea comprehension.

The objectives of this research were described according to the model suggested by Wieringa [9]: **Improve** <*educational planning in PBL approach for courses in Computer Science*> **by** <*a planning tool*> **such that** <*promote communication, collaboration and holistic view during the planning*> **in order to** <*ensure the alignment between PBL principles and the elements of the educational planning*>.

According to Wieringa [15], a project carried out following Design Science interacts with the activities of design and research. The design of the project, within the DSR methodology, is decomposed into three tasks: Problem investigation, Solution design and Solution validation. These three tasks are called the Design Cycle because researchers repeat these tasks many times during the project to arrive at the solution design. The Design Cycle composes another major cycle in which the result of the Design cycle - a validated solution proposal - is transposed into the real world, used and evaluated. This cycle is called the Engineering Cycle and is composed of the following tasks: Implementation of the Solution and Evaluation of the Implementation.

This research will present the second engineering cycle composed of the 5 tasks, according to DSR: 1) Problem Investigation, 2) Treatment Design, 3) Treatment Validation, 4) Treatment implementation and 5) Implementation evaluation.

1) Problem investigation

Based on the understanding of the problem to be investigated, we carried out the analysis of the state of the art of the investigation domain, the delimitation of the subject, problem setting and the context in which the problem occurs. In order to highlight the research motivation and relevance, we have explicitly described the problem, in a clear, and understandable way.

2) Treatment design

The proposal of two artifact creations is the beginning of this phase: PBL Canvas and PBL Cards. These artifacts support teachers in planning their lessons according to the PBL approach for Computing courses. The main references adopted were the xPBL methodology and PM Canvas. At his point, orientations for filling the PBL Canvas were defined. They consist of the invitation to all involved in the process, together with procedures related to the usage of the PBL Canvas, usage of the cards following the filling of the canvas and about how to answer the questions in each card with a post-it, to be put on the corresponding fields. After prototype creation, their assessment initiated the next task of the method.

3) Treatment validation

The assessments directed to the prototypes have generated

various indications for adjustments in the canvas as well as in the cards that have contributed to improvements in the artifacts. After these adjustments were carried out, a new PBL Toolkit version was generated to be applied in real planning cases in courses using the PBL approach. From these cases, we were able to evaluate PBL Toolkit from the applicability and usefulness points of view.

4) Treatment implementation

This task has for objective the practical application of the proposal of solution in real context. The evaluated archetypes were the PBL Canvas and 40 PBL Cards. Two workshops were organized so that the participants could plan courses using the PBL Planner Toolkit in real situations. This means that the professors who had really participated of workshop had made the planning of the courses where they act as professors or tutors or coordinators. Table I summarizes the implementation context.

TABLE I: DSR CYCLE 2 TREATMENT IMPLEMENTATION SUMMARY

Workshops	Courses	Workloads	Contexts	Institutions
1	Personal Development and Employability	60h	Postgraduate Course	College A - Private
	Internet Application Development	80h	Postgraduate Course	
2	Software Engineering	80h	Undergraduate Course	College B - Private
	Project Management	60h	Undergraduate Course	

5) Implementation evaluation

The Evaluation of the Implementation of the solution verified six aspects: Usability, Functionality, Design, Understanding, Collaborative Work and Satisfaction. The data collected through observations were recorded in a logbook which is an instrument for notes of activities, reflections and observations of the observer.

To verify the result of the planning, a checklist was developed adapting an instrument called PBL-Test [16] that evaluates the maturity of the PBL process in the execution of its principles. The checklist consists of 10 multiple-choice questions, referring to the principles, which were filled from the perspective, perception and experience of the author of this research. Each question is associated with three statements that correspond to the following scale of values: 0 (Does not meet the principle), 0.5 (Partially meets it); 1 (Fully meets it). On this scale, the score for each question is related to one these values.

And for each course evaluated, a score of 0 to 10 points can be obtained. At the end of the planning process, all the checklist responses are computed from the sums of the scores and thus enable a preliminary assessment to be carried out to verify the level of adherence of the PBL principles to the planning of the courses: 1) level 0 or insufficient <7); 2) level 1 or initial (7 ≤ poits <8); 3) level 2 or regular (8 ≤ points <9); 4) level 3 or good (9 ≤ points <10); and 5) level 4 or excellent (points = 10).

Once the level has been identified, it is the responsibility of the educational planning stakeholders to identify strategies that can be implemented considering the principles that have the greatest impact on course planning.

Details of the Engineering Cycle Implementation Assessment task will be described in section IV.

III. A MODEL BASED ON CANVAS AND ON INSTRUCTIONAL CARDS

In [17] the authors defined a toolkit that consists of a Canvas-like board, divided into 11 fields and a set of 40 instructional cards, specifically related to each canvas field called PBL Planner Toolkit. A digital version of PBL Toolkit is available at http://www.pblplanner.com.

Fig. 1. PBL Canvas.

Below we present a card, to exemplify its basic structure.

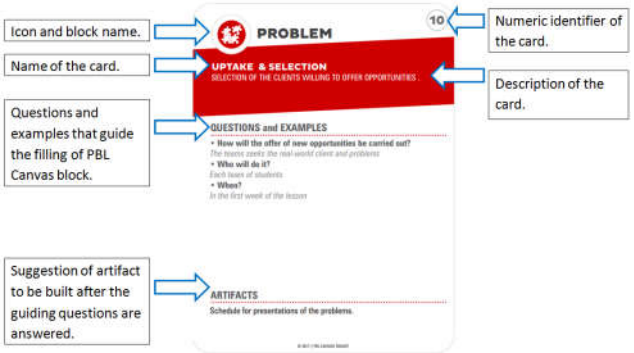

Fig. 2. Example of the Back of a PBL Card.

Each of the 40 cards possesses the same structure. The front of the card possesses three relevant information that stem from PBL Canvas: the field name, the color, and the icon to which it is related in the field. This was done to make the association

between the cards and their respective fields in the PBL Canvas easier. Thus, all cards of the same field have the same associated color and icon. The structure of the back of the card is shown in Figure 2 and contains six pieces of information: name and icon of the related Canvas field; name, identifier and description of the card; questions that guide the filling of the PBL Canvas together with examples of answers to the questions; and finally, the artifacts that may be generated when planning is actually carried out.

Course planning within the PBL approach using the toolkit is divided into 3 phases: Planning, Revising, and Sharing.

A. Planning

The Planning phase consists in conceiving or filling up the PBL Canvas by adequately answering each of the questions contained in the PBL Cards. Table II describes the list of cards for each field in the Canvas. It is subdivided into three stages that must be executed each at least once. In order to carry out this stage, the participation of those who will act in the course as teachers, tutors and coordinator is fundamental.

TABLE II: FIELD DESCRIPTION AND CARD RELATIONSHIPS

Field	Cards
Course	(1) Basic descriptive; (2) Pre-requirements
Objectives	(3) Educational Objectives; (4) General Aims of the Course; (5) Methodological Objectives
Success Indicators	(6) Success of the Teacher; (7) Success of the Student; (8) Success of the PBL Method; (9) Success of the Course
Problem	(10) Uptake & Selection; (11) Textual Description; (12) Presentation; (13) Validation; (14) Alterations
Environment	(15) The ICT Infrastructure; (16) Physical Infrastructure; (17) Virtual Environment
Human Capital	(18) Client; (19) Student; (20) Professor; (21) Technical Tutor; (22) PBL Tutor; (23) Coordinator
Content	(24) Educational Module; (25) Source of References
Assessment Learning	(26) Assessment of Lessons; (27) Problem-Solving; (28) Assessment of Result; (29) Performance Assessment; (30) Assessment of Client Satisfaction; (31) Teaching Assessment; (32) Assessment of Methodological Objectives; (33) Evaluation of the Course
Processes	(34) Forming Teams; (35) The Learning Process
Schedule	(36) Schedule for the Lessons; (37) Schedule for Assessments; (38) Milestone Schedule [Delivery Software]
Risks	(39) Methodological Risks; (40) Academic / Administrative Risks

01) Objective and Goals

The first stage of the completion of PBL Canvas consists of the introduction to planning. It is composed by the fields Course, Objectives and Success Indicators, in these orders. These fields define the context of the course to be planned as well as the objectives and goals to be attained. Planning participants must answer the questions of cards 1 to 9 and affix the answers in the corresponding fields. After affixing the answer to card 9, the first stage of planning is completed.

02) xPBL Elements

Stage 2 corresponds to the fields originated in the xPBL methodology, namely: Problem, Environment, Human Capital, Contents, and Learning Assessment. These are the central planning elements that are most intimately related to the PBL Method. The alignment between the methods and tools for managing the PBL approach in teaching computing stems from planning these fields. The completion process is identical to stage 1, beginning from card 10 and going up to card 33.

03) Processes and Monitoring

In stage 3, we complete planning with the Process, Schedule and Risks fields. These fields are jointly responsible for the definition of the learning process based on the problem resolution to be followed, classroom agendas, assessment and deliveries agenda, as well as the identification of risks that may jeopardize the success of the course as a whole. The cards for filling this field range from numbers 34 to 40. After card 40 is answered, the canvas is completed. Figure 3 shows an example of the finished PBL canvas.

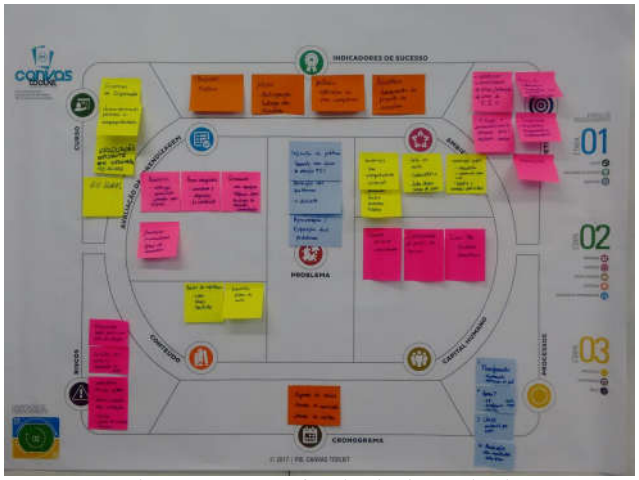

Fig. 3. PBL Canvas after planning is completed.

Table III below presents, for each field, some questions and answers regarding the planning of a course in computer science.

TABLE III: EXAMPLE OF QUESTIONS AND ANSWERS OF PLANNING.

Fields	Some example of questions and answers
F1	Area of Activities? A: Software Engineering. Work schedule and duration of course? A: 60 hours in 4 months.
F2	What non-technical skills (personal, management and business)? A: Leadership, teamwork, initiative, communication, innovation, business processes.
F3	What is the purpose of assessing the success of the student's performance? A: Obtaining 70% on average with regard to 5 factors: Mastery of the content, capacity for problem-solving, standard of work submitted, interpersonal relationships and customer service.
F4	How will the offer of new opportunities be carried out? A: The teams seek the real-world client and problems. What information should be included in the description of the problem?

Fields	Some example of questions and answers
	A: Mastery of the problem, public target, needs of the clients, importance of the problem.
F5	What space is required to run the course? A: Classroom adapted to a capacity of 40 students. What kind of architecture is needed to create the right environment? A: Tables and chair laid out in a way to allow teamwork.
F6	Who will be the client? A: Company XYZ. In what way will he/she be involved? A: In the workshop of opportunities, evaluations of satisfaction and final presentation.
F7	What are the educational modules of the course? A: 1) Planning, 2) Monitoring. What contents for each educational module? A: For module 1) Planning software projects. For module 2) Schedule, Costs, Risks, Communication.
F8	What criteria will be used to evaluate the content? A: Understanding the basic concepts of the projects, the life-cycle, processes and critical factors.
F9	What are the criteria for splitting up the teams? A: Level of training, skills, professional experience and close affinities. What learning process should be followed? A: The 4-stage Barrows PBL (Proposing, Discussing, Resolving and Assessing).
F10	What will be the schedule for the classes? A: Classes will take place every fortnight on Fridays (19:00 to 22:00) and Saturdays 08h to 18h). The course will last 18 months.
F11	What are the relative risks to the objectives and the defined preconditions? A: Badly-defined objectives What are the risks with regards to the learning process? A: Scope of an inappropriate problem.

B. Revising

The Revising stage aims at answering any doubts that may have remained during planning, as well as at completing any card question that was now answered. Once the canvas is filled, planning needs to be revised, to verify dependencies between fields, such as, the defined objectives and the assessments that will measured how much and which objectives were attained. Besides dependencies, we need to check whether there are any undefined or unanswered points, either due to a lack of consensus or even due to a lack of knowledge about the subject.

C. Sharing

Once revising is done, we need to share what has been planned with the involved actors. To this end, a plan of action with the activities and artifacts forecast during plan construction in PBL Canvas, such as course plan, schedule, lesson plan, assessment spreadsheet, etc, should be created. To create the plan of action with the activities from the planning, the following fields are suggested: Tasks, Deadline, Status, and Person in Charge. Activities to be carried out are recorded in the tasks field. In the deadline field, the final date for task completion is recorded. Status field indicates the status of the task. For instance, the following status may be indicated: to be done, done, ongoing and cancelled. Lastly, the person in charge field records the person responsible for carrying out the tasks.

With the creation of the plan of action, a version of the teaching plan in generated (baseline), that may undergo adaptations and improvements along its execution. An example of this simplified plan can be seen in Figure 4 below.

Nº	Task	DeadLine	Status	Owner
01	Create worksheet for student profile mapping, to be used in team formation			Paula Souza
02	Presentation of the Delisle Model			João Silva
03	Create discipline Facebook			Marina Ferreira
04	Draw resolution problem process			Lucas Mendes
05	Create Discipline dropbox with link on Facebook page			Paula Souza
06	Create class WhatsApp group			Lucas Mendes
07	Create PBL Presentation - Dynamics			Paula Souza
08	Create student participation assessment form (self-assessment and teacher / tutor			João Silva

Label: To do Done Doing Cancel

Fig. 4. PBL Canvas after planning is completed.

IV. CASE STUDIES

Two workshops were carried out for data collection. They consisted of a presentation of the PBL Toolkit objectives and functioning, and an alignment of PBL concepts.

College A, through the coordinator of the bachelor's degree in Information Systems, had the initiative to look for the author of this research to carry out a PBL educational planning workshop for the professors of the course that lasted two days - 6 hours in total. As for College B, some professors of this institution sought the author of this research, wishing to learn about PBL. These professors were organized to attend the PBL educational planning workshop which also lasted two days with a total of 10 hours.

The profile of the participants, that is, those who participated in all the stages of the workshop and answered the research, in general, considering both Colleges, is a Higher Education professor with an average of 5 years experience. In terms of degrees, there were 3 specialists, 6 masters and 1 PhD. In addition, 5 professors stated that they have low PBL experience, that is, they have already heard about it and know only the definition and the concepts. Another 3 professors stated that they had an average experience, that is, they already read about the methodology and they had some experience either as a teacher or student, and 2 professors said that they had a high level of experience with PBL, that is, they already used and learned how to apply the method.

During both workshops, professors were divided into two groups, one group for each course. The goal was for each group to plan teaching using the PBL Toolkit collaboratively, for a course given by a member of the group. In each workshop there was a facilitator, e.g. somebody with practical and theoretical experience with the usage of the PBL method to guide group members during planning, and to foster everybody's participation.

The planning phase occurred very similarly in Colleges A and B. Whenever there were doubts about any of the fields in the CANVAS or on any of the PBL Cards the workshop mediator was called and clarified the doubt.

The professors of the Internet Application Development course had less doubts than the professors who were planning the Personal Development and Employability course, that is, they rarely appealed to the facilitator. This is due to the fact that when in doubt, they followed the example given in the PBL Cards. On the other hand, the professors of the courses of Software Engineering and Project Management had a lot of doubts during the entire planning phase especially in the fields of objectives, assessment learning and processes.

The review phase was carried out very quickly. For in all four courses of the two colleges there were practically no fields or cards missing to be contemplated in the planning.

Finally, the sharing phase took a little longer because it was necessary to identify all planned activities and to create a table identifying the activities, people responsible for them and the definition of the periods for realization. In both institutions this phase happened on the second day of the workshop. After finishing this phase and not having more doubts or pending actions on the part of the teachers, the planning of the courses was considered finished.

Data collection happened in two ways: qualitatively, through observations made by the researcher during the whole planning process and quantitatively, after the completion of the planning, applying a checklist.

The quantitative evaluation was carried out with the application of a checklist by the author of this research to verify the level of adherence of courses planning to PBL principles after applying the checklist. Table IV shows the levels.

TABLE IV: LEVEL OF ADHERENCE OF COURSE PLANNING TO PBL PRINCIPLES.

Principle	Course 1	Course 2	Course 3	Course 4	Total by Principle
1	0,5	1	0,5	0,5	2,5
2	1	0,5	0,5	1	3
3	0,5	0,5	0,5	1	2,5
4	0,5	0	0	0,5	1
5	1	0,5	0,5	0,5	2,5
6	0,5	1	0,5	0,5	2,5
7	1	1	1	1	4
8	1	0,5	1	1	3,5
9	1	1	1	1	4
10	0,5	1	1	1	3,5
Total by course	7,50	7,00	6,50	8,00	
Category	Level 1: Initial	Level 1: Initial	Level 0: Insufficient	Level 2: Satisfactory	

Among the 4 courses planned, only course 3 scored low (6.5), indicating that the planned teaching process is not adherent to the PBL principles. Courses 1 and 2 scored (7.5) and (7.0) respectively and these scores indicate that both course plans are weakly adherent to the PBL principles. Finally, course 4 scored (8.0) indicating that course planning is significantly adherent to PBL principles.

It is possible to observe that the principle 4 (Authenticity of the learning environment) was the one that got the lowest score due to the fact that the learning environment is partially conventional (furniture and resources) and partially real (software, tools, processes) as it was possible to observe in the planning of courses 1 and 4. In courses 2 and 3, the planned environment is totally conventional.

The principles with the highest scores were 7 (Evaluation and analysis of how the problem was resolved) and 9 (Collaborative and multidirectional learning.) In all the planned courses these principles received greater care in their definition.

Principle 7 is related to the evaluation process in which the Cards PBL instruct, based on the xPBL methodology, the definition of all aspects necessary for an appropriate evaluation in the PBL approach. In this way, it was clear in the planning of the courses they all contemplated in the planned evaluation process, the verification if the students will build solutions from an investigative and questioning process of ideas among all the members of the teams.

Regarding principle 9, all four courses planned their learning processes for discussion times, group dialogues, and interaction with peers, teachers and tutors to provide collaborative, multidirectional learning.

Principles 8 and 10 also achieved a high adherence rate in planning. The principle 8 (Reflection on the content learned and the learning process) only the planning of the course 2 did not have the total adherence because, although students had opportunities to reflect on their learning, the sending of feedback of the teachers to the students for the development of self-awareness skills about the process of knowledge construction was not foreseen.

Regarding principle 10 (Continuous Assessment), the lack of total adherence was due to the reason for course 1 not having its educational objectives formally defined and thus, could not verify its reach through the evaluation process.

In the following, the qualitative evaluation that was done during the accomplishment of the 2 workshops in the two colleges will be presented. The qualitative evaluation was grouped into six aspects discussed in the next subsections.

A. Usability

With regards to this aspect, Prof_10 said that with the use of the "*planning becomes very productive* and interesting". Another observation regarded the perception of the lack of correlation between fields, especially between objectives, success indicators and learning assessment. This situation made some professors complain about having to make adjustments in correlated fields. Prof_06 affirmed: "*if you change anything, you have to change all the rest, since they depend on one another. An example is the quantity of assessments."* Prof_11 said: "*I have noticed that the alteration*

in any phase of planning has a moderate impact on the following, especially if planning is at an advanced stage." Prof_10 said: "*Despite the fact that instructions are clear, I suggest an improvement on the initial flow. In the case that the user does not read the instructions before beginning, the ways to follow to fulfill the canvas may get lost.*"

The facilitator intervened when he noticed the issue and explained how the professors should carry out the adjustments. The facilitator has also contributed during planning suggesting how the professors could organize the completion of the canvas, suggesting that they could number answers according to the card number that was being answered and to use only one post-it per card.

B. Functionality

During the Planning Workshop, we have observed that the participants approved the artifact that resulted from planning using the canvas, as Prof_13 says "*With this list, I can now know the next steps to put the planning into practice."* Another observation we have registered regards the discussions amongst the participants about the aspects encompassed in the canvas. The tool enabled the participants to discuss along the execution about the topics relevant to the planning. However, there was also the facilitator's perception regarding the need for a more descriptive, detailed presentation about the usage of the Toolkit before starting the planning step. The execution was interrupted a few times by the participants due to their lack of understanding of some fields.

Two professors commented about the filling sequence of the Canvas, informing that they had decided to follow another sequence of steps of their own choosing, as Prof_04 affirms: "*Although there is a sequence, I felt more comfortable using a mix of sequence and interactive process where I could come back and review some Canvas' areas."* Prof_03 also says: "*I would rather use another filling sequence."* It is worth remarking that the sequence prescribed by the PBL Canvas is a suggestion that aims at making its usage easier, but it is not the only way of executing the planning.

C. Design

There were many compliments about the aesthetics, card and canvas format and a few comments suggesting adjustments were observed during the workshops.

Prof_10 complimented saying that "*The visual aspect helps a lot."* and suggested that "*The number/pagination of the card could have a greater highlight. The [example] tag could be included in the examples cited for each question.".* Prof_01 made the following compliment about the toolkit: "*I liked the card colors mapped for the Canvas."*

D. Understanding

The importance of the Facilitator (a PBL expert) became evident during the workshop, as shown by the comments of several professors. One such example is Prof_11 affirmation: "*I needed help several times to understand the applicability of some steps described in the cards."* The fields where the professors had the most doubts where success indicators, objective and learning assessment. Although the toolkit is indicated to any professor in the Computing field, it is important that they strive to learn about the PBL method to use the toolkit, as Prof_04 says: "*It is better used when one has a basic notion of PBL."* Prof_10 has also made a remark to the same end: "*…before anything, one must understand the purpose of PBL before using the CANVAS and solving a problem efficiently." "… an introduction about PBL and the Canvas' benefits is needed."* We also noticed that many professors mix up the meanings of plan and planning. According to the professors' understanding, the action of filling a document in a format similar to a form that is normally asked by the institution and that is called course plan is equivalent to carrying out a planning. However, planning is an activity that goes well beyond filling in a document. It is a systematic, objective, rational, reflexive and collaborative action.

E. Collaborative Work

Collaborative work was quite intense, since group participants took part in the planning process actively, interacting with others, and striving to obtain a consensus to better define the points tackled. There was real cooperation within groups, with task division. While one of the members read the card description, another wrote down the answers after the group agreed about the better answer. More experienced professors contributed by sharing their previous experiences with planning, and that made the workshop rich in information.

Communication amongst the members was, for the most part, free and open. All participants could have a view of the whole planning in order to come to an agreement about the group decisions. Points of disagreement were discussed until a consensus was reached. However, there was an incident in one of the groups where all participants were from the same institution and that also included one of the directors. The director intimidated the others by how harshly he countered a suggestion of another participant, who was suggesting that they defined the educational goals. The director answered Prof_15: "*This is not how we define an objective! You are wrong!"*. Upon noticing the situation, the facilitator tried to minimize the intimidation, and commented about how important the free participation of everybody was.

F. Satisfaction

Participants' comments encompassed compliments regarding the clarity of shared information, ease of use of the toolkit and PBL implementation proposals in the academic environment. Some of these affirmations are shown below: Prof_13 says: "*I have participated in several courses about education methodologies and this was the best. All information were clear and I thank you for providing us with this experience."* Prof_17: "*I did not know the PBL method*

and I liked it very much. College's doors are open for anything you need."

All professors affirmed that they would recommend the usage of PBL Planner Toolkit to other professors. They also remarked that it is an excellent tool for those who wish to know where to begin to adopt the PBL method in their Computing courses.

V. CONCLUSION

Educational planning according to the PBL approach has specific requirements that make planning a little more complex than usual. There are challenges, in particular in what concerns the management of the teaching and learning process, since the PBL methodology is very different than the traditional teaching methods. This requires a new attitude from both professors and students'. PBL adoption stands a better chance of being effective when it is well planned and monitored so that there is an alignment between theory and practice.

In order to help professors in the educational planning activity, we have created PBL Planner Toolkit, a toolkit that helps the professor in planning the adoption of PBL. The tool consists of a Canvas (board) divided into 11 areas as well as by a set of 40 cards that guide the completion of the Canvas and the execution of the planning, based on the PBL methodology [13].

The initial results obtained indicated that PBL Planner enables PBL planning and tackles all required aspects, such as collaboration, cooperation and communication among the actors involved in the activity. It has also shown to have good usability and acceptance by the professors. Some improvement points were identified, such as legibility and dependence between fields. These will be analyzed to define the best strategy to adjust and evolve the toolkit.

Regarding the results of the adherence of the PBL principles to the planning of the courses, it is important to emphasize that even though course 3 obtained the lowest score of the adherence level, this does not mean that the course will be a bad course. In the same way that courses 1, 2 and 4 that obtained higher indices will be good courses with a high level of maturity in the PBL process.

The PBL Planner toolkit does not guarantee that the course will be good or bad, nor whether planning will be well or poorly performed. But it is a good tool to assist in planning courses in the PBL approach in order to stay focused on the vital points for a course in this approach. Specifically, it helps focus on the guiding principles of the PBL approach.

Toolkit evaluations and course planning results indicate that a carefully planned course, using the PBL Planner Toolkit, and at the end of the planning, achieves a high level of adherence to the PBL principles, is more likely to be successful if you follow what was planned during the course.

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