Using a Virtual Learning Environment for Problem-Based Learning Adoption: A Case Study at a High School in India

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Abstract- ***Problem Based Learning approach (PBL) is an instructive constructivist method which promotes, as its main feature, the use of real life problems to initiate and motivate the comprehension of new concepts, stimulating the abilities and actions that are needed for the solutions of such problems. PBL is strongly fundamented in well defined principles. Thus, it is fundamentally important that teachers and students implement PBL in conformity to its principles. Once these principles are addressed, PBL brings a collaborative and interactive learning process between all participants. On the other hand, many teachers and students implement PBL without the necessary theoretical and practical base for the educational changes and appropriate technology resource support, putting PBL's quality and authenticity at risk, making it less efficient. In the attempt to overcome these challenges, this paper presents the usage of a virtual learning environment called PBL-Coach, which promoted technological support to an array of actions based in the principles and characteristics originated from learning theories about PBL in a year 8 class of Physics at Tara International School, in Raison, Himachal Pradesh, India, with the objective of helping teachers and students in the implementation of an authentic learning process with useful and relevant technological support. The implementation of PBL at Tara International School brought satisfactory results, reflected in the students' high level of learning, which was demonstrated in the 360 degrees evaluation and in que quality of the solutions for the problem. This experience was also inspiring for other teachers and students that became involved with the methodology. Since this was a short term learning experience implemented for children, only a full 3-week PDCA cycle was executed, along with metrics such the students' performance and understanding, the curriculum exploring and teamwork, problem resolution, presentation and 360 degree evaluation.***

Keywords Problem-Based Learning; Virtual Learning Environment.

I.INTRODUCTION

Problem Based Learning approach (PBL) is an instructive constructivist method which promotes, as its main feature, the use of real life problems to initiate and motivate the comprehension of new concepts stimulating abilities and actions needed for the solutions of such problems [6]. Constructivism argues that human knowledge is a product of social and physical interaction between men and its environment [1]. Therefore, a PBL teaching approach is based on the student assuming an active role on the teaching-learning process through observation, experimentation, comparison and teamwork within real learning contexts and environments.

PBL effectiveness is directly connected to its methodology and management tools by which planning, support and improvements to the approach can be achieved continuously during its application [5]. Once effective, PBL can provide an encouraging learning environment for teamwork involving, tutors, professors and students, developing a great capability for analysis and problem solving.

One of the main challenges found on the implementation of the PBL approach is the difficulty on building and sharing collective knowledge from teamwork, allowing the professor to assist each associate individually. [5] continues saying "it is common knowledge that tutors face difficulties in fairly assessing individuals within groups as some students choose not to contribute".

These disagreements may lead to unwanted tensions within groups and may force some students to disengage and take the "free-rider route". This issue is directly related to lack of engagement from some students in difficulty to collaborate with their group, mostly for taking other work or study related commitments or because of the need for activities and environments that promote a complete immersion on the course for the students, bringing them to the center of the learning process continuously [5].

Bearing this challenges in mind, this paper aims to show the use of a virtual learning environment called PBL-Coach, which promoted technological support to a set of actions based on the principles and characteristics derived from PBL learning theories with the aim of assisting teachers and students in implementing a learning process, mitigating problems related to lack of time/knowledge and promoting collaboration and student satisfaction when achieving the desired goals.

A case study was conducted in the eighth grade class in Physics discipline at Tara International School in Raison, Himachal Pradesh, India. with the aim of assisting teachers

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and students in implementing a quality learning process, where students work in groups and present their problem solutions to other groups, inspiring their curiosity and interest to learn. The students received continuous feedback from the teachers, answered questions related to Physics and did a 360 evaluation, assessing the skills that were developed throughout the process, such as understanding the problem, ability to work in groups, listening to the group, talking to the group and being proactive. This case study, described on section 3, presents results proving the effectiveness of the model and indicates improving points for new experiences. Lastly, final considerations are presented on section 4.

II.THEORICAL BASIS: PBL AND VLE

PBL is a teaching-learning method in which the students are immersed in a practical environment where they develop a proactive mindset and establish relations with other learners [5]. Although PBL is based on principles, it does not define a single methodology for their application within an educational setting.

In [6], the authors put forward a methodology called xPBL, with the aim of ensuring that when PBL is employed for the teaching of Computer Studies, it is implemented in an effective, authentic and rigorous manner. According to the authors, the authenticity of the learning environment for PBL can be preseerved if the following factors are taken into account: 1) the adoption and practice of real problems; 2) the definition of the human resources involved, together with their clearly defined functions and responsibilities; 3) theoretical content aligned with problem-solving; and 4) the adoption of the kind of development processes and assessment procedures employed by the market; 5) those involved are within an environment that reflects the reality of the job market [4]. By preserving the learning environment and faithfully adhering to the guidelines of the PBL methodology, what is taught to the students can be rendered much more effective as a means of preparing them for their professional lives.

In [3], the authors show that it is possible to ensure that PBL is adopted in an effective way when it follows the stages of a well-defined process that encompasses planning, execution, monitoring and assessment and is geared towards making continous improvements. These stages rely on the PDCA cycle (Plan, Do, Check and Act), which is a methodology that is basically designed to assist in the diagnosis, analysis and prognosis of organizational problems, and is ideally suited to the management of the teaching/learning process in PBL.

A. Virtual Learning Environments

According to [4], a VLE (Virtual Learning Environment) is known in the literature as a software tool which combines "several tools and functionalities: content management; participant management; channels of communication such as forums, chats, e-mails, etc.; and task management". However, these components are only of general use and are hardly ever combined with a clear learning process. When examining a student-centered teaching method like PBL, the students must be capable of making decisions with regard to their manner of learning. This means being prepared to be guided by one´s environment and taking control of this process, rather than allowing oneself to be lost in an environment with countless functionalities and without knowing for certain what to do with them.

In [6], the author stresses that a VLE that is suited to PBL must be geared towards teamwork and be focused on a discourse thast is concerned with the collaborative construction of knowledge. The author defines a particular term for this environment, "CMCPBL" (Computer-Mediated Collaboration for PBL). This refers to three significant features of this discourse and uses the work of [7] as a benchmark: 1) A focus on the background of the problems and an in-depth understanding of this problem; 2) Construction of open and collaborative knowledge; 3) Inclusion of all the participants in the learning process.

Despite all the benefits for the academic world and hence for the practical life of institutions in the outside teaching world, the large number of studies on thos issue have given rise to several problems. These include the following: the use of an inappropriate terminology and concepts for PBL; the use of experiments that have not been validated and lead to doubtful conclusions ; studies that fail to take into account the principles of PBL; the lack of technological tools that can support PBL in an effective way; and the difficulty of making use of the existing environments.

III.PBL-COACH: TECHNOLOGY AND EDUCATIONAL METHODOLOGY

Observing the PBL-Coach objectives described on this paper's introduction, the present environment was defined observing 3 educational principles consonant with the PBL approach: 1) Student centered environment; 2) environment allowing problem proposition, discussion, understanding and development; 3) collaborative environment that stimulates interaction and immersion of everyone involved on the teaching-learning process.

Figure 1 presents a conceptual view of the model, based on its references and characteristics.

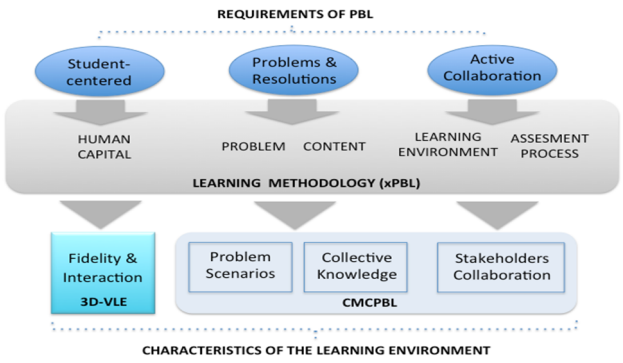

Figure 1: Conceptual view of the model.

The educational goals represent PBL requirements, based on the main challenges discussed by [4]. Those goals are associated to xPBL elements, used as pedagogic background to achieve such goals. Using this association as start point, characteristics for learning environments were defined, using current virtual learning environments and its differences (CMCPBL) as reference, so as to enable xPBL to be supported by those environments.

B. PBL-Coach and the PDCA cycle

Before outlining the main activities that are included in the technological resources and interfaces of PBL-Coach, the set of activities included in the management of the teaching and learning cycle should be made clear, since they rely on the PDCA cycle as a benchmark and there is a relation between these activities and the PBL principles.

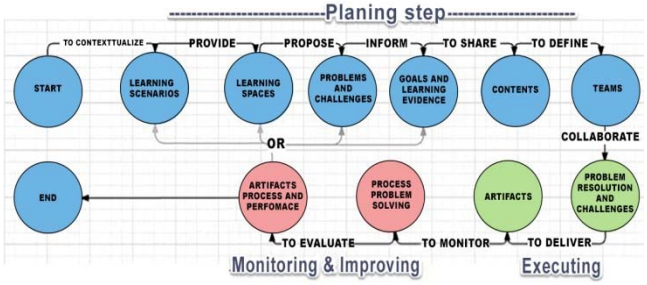

Figure 2 : Set of Activities.

The explanations set out in Figure 2 are defined in Table 1 which displays the activities and the ways they can be described. These activities are carried out in the PDCA cycle to ensure that there is a standardization of each stage, as it is started, developed and completed, for both the teacher and the students.

TABLE 1. DESCRIPTION OF ACTIVITIES

The Planning Stage	
Activity	**Description**
01 – Learning Situations	The teacher must contextualise the learning situations so that they correspond to real circumstances and allow him/her to reflect on a situation where the students should be enabled to interact in the interests of their learning. The students must be given support when working in a complex situation.
02- Learning spaces	The teacher should make a place available for the studentswhere they can do research and share technology; this can tehn be used in an environment that is especially designed to encourage collaboration.
03- Problems and Challenges	The teacher, client and tutors (technical and PBL tutors) should set problems that challenge the students to seek to explore matters that are based on real situations and attract their interest. A challenging problem raises issues that must be solved by the students and should entail a wide range of activities and be tackled by drawing on various kinds of information.
04- Goals and Evidence of Learning	The teacher should define the learning objectives and this involves describing observable knowledge and the skills that must be demonstrated by the students, such as how to tackle challenging problems.
05- Teaching content	The teacher/lecturer should share text-based files, presentations, spreadsheets and so on.
06- Teams	The teacher should form heterogeneous teams in which the different skills of each member can be combined to achieve results.
The Execution Stage	
07- The Challenge of Problem-solving	The student should disclose his knowledge and draw on facts, suppositions and ideas with regard to the challenge-problem. He should also define the tasks that are required to cater for the needs of the team, be involved in problem-solving and handle the different stages of the workflow.
08- Artifacts	The student must write web-based documents, create spreadsheets and give presentations , among other kinds of collaborative work.
The Monitoring Stage	
09- Problem-solving	The teacher should find out what difficulties students have with their problem-solving activities, deal with any queries, provide feedback and check the solutions arrived at by the teams. He/she should also observe to what extent each student/team is involved in the activities .
The Continuous Improvement Stage	
10- Problem-solving	The teacher should assess the lesson content, procedures, artifacts and performance in front of the student.

C. Main Technological Resources and Interfaces

Technological resources provide opportunities to enhance the participation of the teachers and students and, as a result, make them suited to the kind of teaching and learning employed by PBL. In the following section, there will be an examination of the technological resources and main interfaces that offer support to a set of structured and measurable activities based on the principles and key elements of learning theories about PBL (in accordance with Tables I).

The Teacher Module : Figure 3 shows the interface of the key teacher module. This module allows the teacher to carry out the planning and management of the following: learning scenarios, problems, challenge-problems, learning objectives, evidence of learning, teaching content, the learning environment, teams, the monitoring of the learners to detect if any learning difficulties are being encountered. At the same time, it determines if the educational objectives are being achieved.

Figure 3: Interface of the main module for the teacher

Student Module : Figure 4 shows the interface of the main module of the student. This module allows the student to produce a challenge-problem, suggest a means of tackling the problem, carry out tasks, create artifacts and work in a collaborative way.

Figure 4: Interface of the main student module

Resources for the Management of Problems and Challenges: Figure 5 shows the interface for the management of problems and challenges. This resource makes it possible to store problems in a shared repository and carry out searches that cover a wide range of information of interest . It will also make it possible to visualise the problems through specific information contained in the guidelines for tutors which should not be shown to the students, as well as to plan or choose new problems on the basis of pre-existing problems.

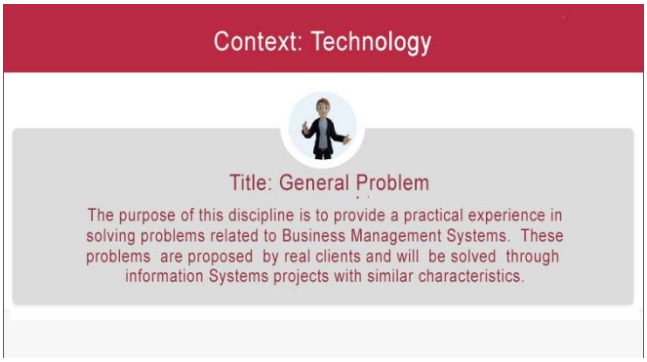

Figure 5: Interface of the resources for the management of problems

Resources for the Analysis of Solution: Figure 6 shows the interface chart for the analysis of solutions. This resource provides a framework which establishes the analytical procedure for monitoring how students find solutions to problems. It also offers the students a means of thinking about a problem in depth and reaching a conclusion by means of the following sequence of stages: i) Ideas – possible ways of solving the problem ; ii) Facts – information that has a bearing on the problem; iii) Suppositions – raising questions about learning to help solve the problem; and iv) Action Planning - strategies , resources, and information, i.e, whatever can assist in finding a solution.

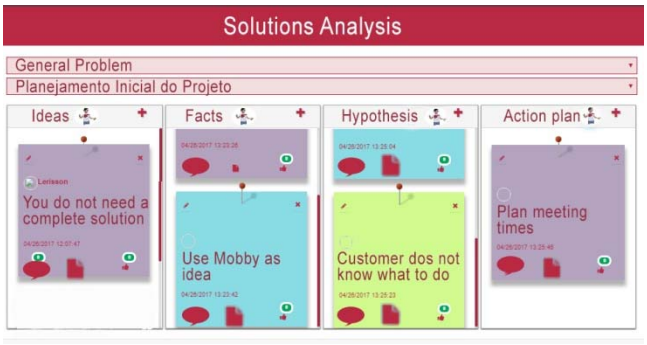

Figure 6: Interface of an analytical chart for finding solutions

The idea for the creation of a VLE to support PBL approach came from a research project where the objective was defining a framework for PBL approach implementation on computer science teaching. This framework, which is still under development, is built upon three great pillars: 1) a PBL methodology based on support processes and tools; 2) support given by Information Technology to the teaching-learning process; 3) a capacitation program for the dissemination of the approach, methodology and technology used to all stakeholders. The model here proposed, called PBL-Coach, Is detailed in a publication in progress at this conference.

IV. THE CASE STUDY

Every three years, the Organisation for Economic Cooperation and Development (OECD) promotes the Programme for International Student Assessment (PISA), an evaluation that assesses students from all over the world in Sciences, Mathematics and Reading. The state of Himachal Pradesh, India, scored the last position in Sciences in the years of 2009 and 2012, when India decided to no longer participate in the program.

The case study was carried out in Tara International School, a private School managed by Ms. Bala Johnson, which is located in Raison, Kullu, Himachal Pradesh, Postal Code: 115128, India. The school is placed in a rural area of the state of Himachal Pradesh, and the school teaches the primary and middle school subjects in English, since 2004, when it was founded.

Tara International school is financed by the students' parents, who are not able to pay much. In the year 8 class, for example, all parents worked on orchards, and the school monthly fees are 800 Indian Rupees, which is roughly 12 dollars. With this kind of money and in such small classes, it is very hard to invest in the school, so the infrastructure problems were an issue. In spite of these problems, the school had computers with access to the internet, and this is a reality in many schools in India, since the government is now rolling out optical fibre across the country. The computers are not new and they run in different operating systems and have different configurations, many times being recycled and reassembled computers. For this reason, a virtual environment like PBL-Coach would be ideal for applying PBL, since it has the advantage of being a web-based platform.

For this reason, using PBL-Coach would be an easy and effective way of bringing a new teaching methodology and engaging the students at the same time in a colourful virtual environment brought by PBL-Coach.

The students have their first contact with Physics at year 8 and, in 2016, the class 8 had 9 students, which is not usually considered to be a large classroom. They were chosen as subject to this project, given the possibility of creating smaller groups that would have access to internet-enabled computers, making it feasible for them to use the PBL-Coach environment in the school. 2 teachers, engaged in preparing the computers to accommodate the platform and applying the project on site. as shown in Figure 7.

Figure 7: Case study was carried out in the Tara International School

In the Planning Stage (PLAN), given the short available time for the project execution, it was agreed that the teachers would run a full PDCA cycle within the project, starting with the students and teachers introduction, group formation and the problem brainstorm, which raised a few questions, with a choice of "how does a camera work?" as a question-problem. The teachers had access to a specific URL of PBL-Coach and they created a learning scenario with the chosen question-problem. With that in hands, they created one associated challenge: "to plan and create a camera prototype". After this initial selection, the teachers were able to bring together their educational objectives by giving guidance to the students with regard to their learning goals and their choice of strategies to attain them, as well as the materials that would provide support for their chosen problem-solving. Following this, they created groups (3 groups of 3 students each) and invited learners, specialists, or collaborators – depending on the role they played –, to form learning groups. All the invitees were notified by e-mail and supplied with information about how to access PBL-Coach.

The timetable was established with the following stages of the PDCA cycle. Since that was the first time the students had any contact with Physics, it was assessed that an introductory class about the Optics principles focusing on the problem would come in handy. After that, the students would have their first contact with the PBL-Coach tool, which would be used along the project, for the students' research validation and the making of the cameras. At the end, the students would present their results to the other groups and perform a 360 degree evaluation.

[2] propose a model of application of the PBL model within a class of Physics, with the theme "How do we manage to see the objects around us?". Inspired by this idea, along with a brainstorm with the students in the first meeting, they came up with the question: "How do cameras work?", which was the central question for this project. We used the xPBL guidelines proposed by [4] to assess the problem, making sure the issue is relevant and at an appropriate level of complexity, also verifying its compatibility with the year 8 curriculum. The problem was then discussed with the project advisors, who agreed that the issue was innovative, relevant, viable and appropriately complex for the year 8 class. The students had access to the internet throughout the project, and that is where they have found most of the content needed by them. The public school science books, that are the same for all schools in India, were also the base for matching the subject to the syllabus.

In the execution stage (Do), the learners had access to PBL-Coach and began to see the problems that had been set. Moreover, they were able to clear up any uncertainties about the terms, situations, words or expressions they were unable to understand.

Along with the development of the process, the students were advised to access the PBL-Coach interactive environment with their group to see and understand the problems and challenges. The analysis board was then filled in by the students with cards in 4 different rows: ideas (links to websites with videos or steps to make a camera), facts (essential tools and parts for the camera), hypothesis (non-essential tools and parts that would be an increment to the group's camera and that could demonstrate other Physics concepts) and action plan (tasks allocated to each student within the group). When the plan became concrete and got validated, the students were able to transfer each step from the action plan to the resolution board, an Agile board with five rows: to do, doing, done, checked and impediments. This whole process was essential for the students' understanding of the problem.

In this context, the students visualised and coped with the challenges and learned to understand what subjects or issues needed to be studied to overcome them. This understanding entailed identifying learning objectives and issues. Following this, the students revealed their knowledge and investigated facts, suppositions and ideas with regard to the challenge-problem. Each member of the group could remember different things and this turned the discussion into an opportunity to learn. In this context, the students found it important to show respect for their colleagues' opinions. The next stage was to define the tasks which could meet the expectations of the group and assist in the problem-solving. These tasks were transparent in so far as all the necessary information was disclosed to everybody and this improved communication and strengthened the bonds that integrated the group. They also gave presentations in a collaborative manner, as well as the making of the cameras. At the end, the students came up with their prototypes, that were tested on spot. The students had the opportunity to make final adjustments to their prototypes before presenting them to the other groups on the next class. The presentation consisted in the students showing their solutions and answering a few questions that relate what they have done to the Physics contents that were learned.

In the monitoring and improvement stages (Check and Act), the teachers identified any difficulties the students might have had in solving the challenge-problems, analysing results or carrying out tasks. With the teachers and tutors constant support and supervision, along with the "like" button and comment sections in the cards on PBL-Coach, the ideas that the students posted there could be continuously validated. This way, the teachers were able to give positive feedback, guiding the students towards the right path, from the moment they found their first ideas to the moment they actually finished their prototypes. The teachers could also assess the degree of involvement of each group or each student with regard to the activities and conduct an a 360 degree evaluation. a 360 degree evaluation took place between all students. This kind of evaluation was chosen because it provides self evaluation, plus a pairs and teachers evaluation. The teachers also opened up for verbal feedback and suggestions from the students on the project as a whole. PBL-Coach also automatically generates a graph that quantifies how much the students actually entered data, commented and got positive feedback in the software. This production of visual graphs is actually one of the outputs for the process element guidelines proposed by [4].

V.ANALYSIS AND DISCUSSION OF THE RESULTS

1) Students performance and understanding: The students proposed their own solutions, which inspired their curiosity, interest and generated their need to know more [2]. This, along with the use of PBL-Coach to structure the problem using the tools and boards, helped them understand what they knew, what they needed to know and what they had to do, which was the definition of the steps to make their own camera. During the groups presentations, each group answered questions related to their own cameras that required knowledge in Physics. For example, Group 1 presented a camera obscura, and we asked them why the image was displayed upside down in their camera, and they rightfully answered that this occurred because of the principle that light travels in a straight line.

2) Curriculum exploring and teamwork: The students had access to the internet, so they chose their sources. The information exchange was also stimulated, when at the end of the classes the students would share with the other groups what they had found, inspiring the other groups in their research. This way, every group found different solutions, that were validated with the teachers through PBL-Coach. The minimum knowledge necessary to understand and build the cameras comprises the principles of Optics. The most basic camera prototype was presented by group 1, that presented a camera obscura. At the same time, students on groups 2 and 3 tuned up their cameras with lenses and photo paper, respectively, bringing new concepts to the classroom.

3) Problem solving and presentations: After creating the prototype that solves the proposed problem, students presented their work to the other groups. By following the other groups' presentations, all students obtained a complete learning [2]. They also got a final feedback from the teachers by explaining their cameras schemes and answering questions related to Physics.

4) 360 degrees evaluation scores and other metrics: At the very end of the project, the students made the 360 degrees evaluation, assessing abilities that were developed along the process, as the understanding of the problem, ability of working in group, listening to the group, speaking to the group and being proactive. 8 out of 9 students self-scored 10 at their own understanding of the problem (with one student marking herself 9), and 8 out of 9 students were also marked by their group mates with a score equal or higher than 9 in this item (with one student being marked 8 by her group mates). The other abilities had more variations, possibly because working in group brings out these characteristics that are not always matching between all units in a group. The teachers were also highly scored with all averages above 9, with the exception Of one teacher in the speaking to the group item. Other than that, another metric that was very positive was the group ranking graph. At the end, the most sophisticated solution was definitely represented by the highest score on the board.

VI.CONCLUSION

It is well-known that lesson planning is essential when running a course, in particular when the teaching methodology is based on PBL. A course must be well planned, as well as aligned with assessment during the problem-solving activities, in order to ensure that the results of the teaching/learning process is effective and to allow the educational goals to be fulfilled. Despite its obvious benefits, the implementation of a teaching process that adopts this approach is an arduous task that requires the

commitment of everybody concerned, in particular the educators.

The results obtained from the application of Problem-Based Learning in Tara International School portray the students' high level of learning, which was demonstrated by the 360 degree evaluation and the prototypes themselves. This initiative was endorsed by the director Ms. Bala Johnson, who followed the project and was clearly excited with the results. This project was also inspiring for other teachers in the institution, who started to use the laboratories and computer rooms more often. The students were also very excited about this methodology and engaged in their projects, since they did not have to deal with excessive formalisation. Instead, they could learn by investigating and solving a problem.

Conducting this project brought to light the subjectivity of the participants' expectations and motivation. Thus, it can be concluded that the use of PBL-Coach makes it possible to oversee the implementation of the PBL approach. This approach is also able to cater for the needs of a learning environment that is centered on the students and aligned with a learning methodology, management processes and collaborative tools. However, in spite of the positive results, it should be stressed that, although the PBL-Coach was a necessary and powerful condition, it is not the only feature required for an effective learning process. The activities carried out by students during the teaching/learning process determine to what extent learning has taken place and the involvement of the teacher in the environment also helps to foster this learning process.

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