Project Based Learning

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***Abstract* – This article discusses the nature of learning in PBL and examines the empirical evidence supporting it. This paper shares some relevant published evidence that active problem solving by learning teams contributes to critical thinking and effective team communications, which can be carried forward into professional roles in the work place. The curiosity and inspiration that inspired this paper was a research question "How does facilitated problem-based learning benefit a team of distributed learners when collaborating on designing and producing a practical solution?"**

Keywords – **Project Based Learning, Self Directed Learning, Matlab Ford-Fulkerson algorithm, Heuristiclab.**

I. INTRODUCTION

The old-school model of learning facts passively and reciting them out of context is no longer sufficient to prepare students to survive in today's world. Solving highly complex problems requires students to have both fundamental skills and Digital Age skills.

This paper begins with the basic thoughts on Learning based on the Project, as part of the theory of learning from experience. To develop such attitudes and the theory, a long period of time was needed over which knowledge has been divided into theoretical and practical knowledge, with these two segments being integrated only in recent times. In this approach to learning, knowledge is considered to be the product of experience.

This approach is broadly applicable in scientific research where the emphasis is not placed on learning, but rather on problem solving and knowledge transfer between members of the research group. PBL is a big part of modern learning environments. It takes students on a cool journey of creativity, exploration, and real-world relevance.

Problem-based learning (PBL) is an instructional method in which students learn through facilitated problem solving. In PBL, student learning centers on a complex problem that does not have a single correct answer. Students work in collaborative groups to identify what they need to learn in order to solve a problem. They engage in Self-Directed Learning (SDL) and then apply their new knowledge to the problem and reflect on what they learned and the effectiveness of the strategies employed. Problem Based teaches students 21 st century skills as well as content. These skills include communication and presentation skills, organization and time management skills, research and inquiry skills, self-assessment and reflection skills, and group participation and leadership skills. By bringing real-life context and technology to the curriculum through a Project-based Learning approach, students are encouraged to become independent workers, critical thinkers, and lifelong learners. If students learn to take responsibility for their own learning, they will develop in the way to work with others in their adult life. Project-based Learning is not just a way of learning, but a way of working together, Fig.1.

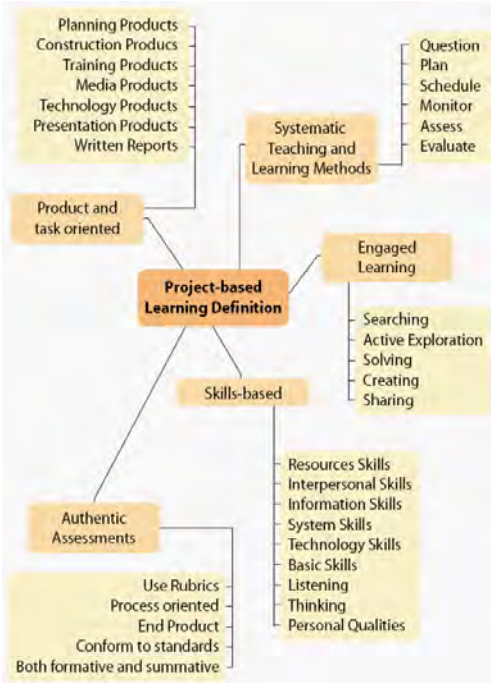

Fig. 1: Project Based Learning at a glance

For many students, the appeal of this learning style comes from the authenticity of the experience. Students take on the role and behavior of those working in a particular discipline. Whether they are making a documentary video about an environmental concern, designing a travel brochure to highlight sites of historical significance in their community, or developing a multimedia presentation about the pros and cons of building a shopping mall, students are engaged in real-world activities that have significance beyond the classroom.

The teacher acts to facilitate the learning process rather than to provide knowledge. Teachers who are used to traditional instructional methods know how to manage a classroom when they're directing a lesson, supervising individual assignments, or leading a discussion. But managing the varied and more team-based, lively activities found in a project might seem daunting to teachers new to PBL.

Project-based Learning is a model for classroom activity that shifts away from the usual classroom practices of short, isolated, teacher-centred lessons. PBL learning activities are long-term, interdisciplinary, student-centred, and integrated with real-world issues and practices. It is a method that fosters abstract, intellectual tasks to explore complex issues. It

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promotes understanding, which is true knowledge. In PBL, students explore, make judgments, interpret, and synthesise information in meaningful ways. It is more representative of how adults are asked to learn and demonstrate knowledge.

The goals of PBL include helping students develop:

1) flexible knowledge,
2) effective problem-solving skills,
3) SDL skills,
4) effective collaboration skills, and
5) intrinsic motivation.

II. How to Implement Project-Based Learning?

A basic and simple overview of the PBL Process is illustrated in Fig. 2, which starts with a buy-in decision that the PBL protocol will add value to a lesson agenda and ends with the problem being solved and documenting a lesson learned. A seen by the arrows, steps are looped until the results are satisfying.

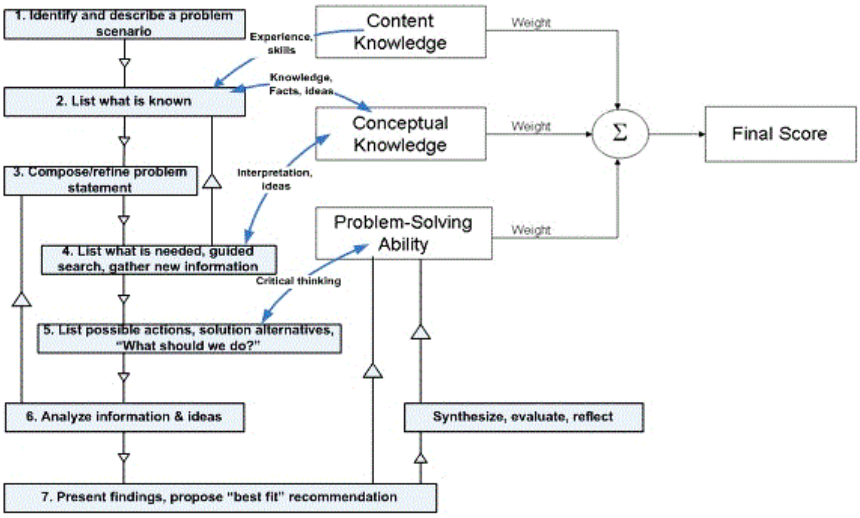

Fig 2. PBL action steps, integrated with course assessment.

Real PBL, by contrast, is deep, complex, rigorous, and integrated where each stakeholder in the school plays an important role. In implementing PBL, its fundamentals are fourfold:

- ✓ Create teams of three or more students to work on an in-depth project for three to eight weeks.
- ✓ Introduce a complex entry question that establishes a student's need to know, and scaffold the project with activities and new information that deepens the work.
- ✓ Calendar the project through plans, drafts, timely benchmarks, and finally the team's presentation to an outside panel of experts drawn from parents and the community.
- ✓ Provide timely assessments and/or feedback on the projects for content, oral and written communication, teamwork, critical thinking, and other important skills.

Characteristics on which project based learning is based are:

- ✓ Any group or individual, within a set of problems, getting special tasks to solve independently,
- ✓ It is desirable that the group is small, or heterogeneous, so that the advanced students can help less advanced students,
- ✓ Project is organized around topical issues that the teacher and students find important,
- ✓ Content topics are organized around problems, not about discipline,
- ✓ Students manage the process of learning. The group carried out field research, studying literature and the like.

The project sets the student in the center of attention, as well as the promotion of his creative talents and possibilities. The student has a maximally active role. When the student is intellectually and functionally active, then he is intellectually developed.

Students address the terms of reference used by the same mindset and the same procedures that are used in science. The project continues to develop the skills necessary in life and work of adults and in everyday life.

Scenario consists of several phases, Table I.

TABLE I
PHASES OF PBL FOR SCENARIO PLANNING

Phase	Purpose
Goal Description	Define a problem scenario to demonstrate course learning outcomes. Establish an ultimate goal for team project.
Specify Criteria	Specify criteria to be met. What is the focus of the testing? How will you know when you have reached your target?
Background Knowledge	Identify knowledge needed to accomplish the goal. Ask experts? Resarch and adapt best practices.
Generate Ideas	Brainstorm & generate ideas.
Implement Solution	Generate, develop and implement an adapted solution(s) for verifying the requirements are validating the system.
Reflect	Evaluate and reflect on your solution(s) and on the process we went thought the lesson learned.
Generalize	Conceptualize, integrate and generalize previous knowledge about system and new learning.

Reflection by students is a time of pause to decide to stay in the loop or to complete the exercise because enough is known, or the time has expired. Reflecting on the relationship between problem solving and learning is a critical component of PBL and is needed to support the construction of extensive and flexible knowledge (Salomon and Perkins, 1989). This reflection should help learners understand the relationship between their learning and problem-solving goals. Reflection helps students to relate their new knowledge to their prior understanding, mindfully abstract knowledge, and understand how their learning and problem-solving strategies might be reapplied.

Project-based learning offers a wide range of benefits to both students and teachers. A growing body of academic research supports the use of project-based learning in school to engage students, cut absenteeism, boost cooperative learning skills, and improve academic performance (George Lucas Educational Foundation, 2001). For students, benefits of project-based learning include:

• Increased attendance, growth in self-reliance, and improved attitudes toward learning (Thomas, 2000)

• Academic gains equal to or better than those generated by other models, with students involved in projects taking greater responsibility for their own learning than during more traditional classroom activities (Boaler, 1997; SRI, 2000)

• Opportunities to develop complex skills, such as higher-order thinking, problem-solving, collaborating, and communicating (SRI, 2000)

• Access to a broader range of learning opportunities in the classroom, providing a strategy for engaging culturally diverse learners (Railsback, 2002)

III. SOLVING PROBLEM OF THE COLLABORATIVE GROUPS

Collaborative problem-solving groups are a key feature of PBL. One assumption of PBL is that the small group structure helps distribute the cognitive load among the members of the group, taking advantage of group members' distributed expertise by allowing the whole group to tackle problems that would normally be too difficult for each student alone. In PBL groups, the students often work together to construct collaborative explanations. Most PBL groups need some help to collaborate effectively.

To solve this problem we can use heuristic method and a modified Ford-Fulkerson algorithm. This algorithm we use to make workflow formation model of heterogeneous groups of students who are learning in a team. To make this possible, it is necessary to create a MATLAB mathematical model. In this model the heterogeneity refers to the characteristics of students. We have taken into account the following features that are easy to identify on the basis of surveys and preliminary results of students: interest in the subject, the performance of the studies (the average), motivation, attitude toward work in a group performance studies on matters related to the subject of learning, Table II.

In order to simplify each of these characteristics a range of values from 1 to 5 is defined where 1 means a low and 5 means a high grade. In this way, each student presents a feature vector whose value ratings from 1 to 5. For example, student S_1 can be represented as S_1 (5, 5, 5, 5, 5). Total student score on the basis of heterogeneity weights is simply the sum of the elements of the vector characteristics.

TABLE II
CHARACTERISTICS OF STUDENTS

Students Group	Interest for the Course	Average Score	Motivation	Attitude toward work in a Group	Matters related to the Subject of Learning	Average
S1	5	5	5	5	5	5
S2	3	4	3	3	4	3,4
S3	4	4	4	4	4	4
S4	3	3	3	5	3	3,4
S5	3	2	3	4	2	2,8
S6	2	2	4	5	3	3,2
S7	2	1	3	5	2	2,6

Fig. 3 shows vector distribution of the students group:

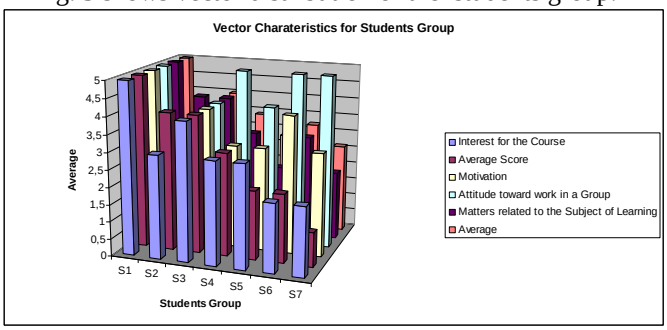

Fig 3. Vector characteristics for Students Group.

In this case, the matrix of mutual links looks like:

Source	1	1	1	3	2	4	5	6	7
Destination	4	6	7	5	4	6	1	2	6
Weights (exaple)	4	3	2	2	3	3	2	3	3

In Matlab we introduce described connected links:

cm = sparse([1 1 1 3 2 4 5 6 7**],[** 4 6 7 5 4 6 1 2 6**],[** 4 3 2 2 3 3 2 3 3**],7,7)**
cm=
(5,1) 2; (6,2) 3, (1,4) 4; (2,4) 3, (3,5) 2; (1,6) 3; (4,6) 3; (7,6) 3; (1,7) 2

And draw the diagram group, Fig. 4:
h = view(biograph(cm,[],'ShowWeights','on'))

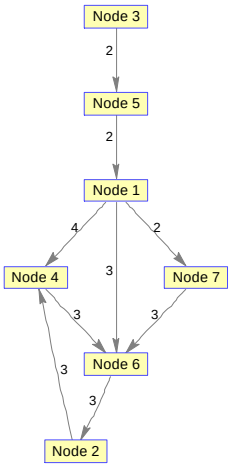

Fig 4. PBL action steps, integrated with course assessment.

Now we are introducing a measure of the quality of the heterogeneity of the group according to the following principle: if from group of N students we remove the best and worst student on the basis of characteristic vectors, the results of other students should be somewhere in the middle compared to these two "border" students. It can be shown that the following formula for quality and heterogeneity of the group i or GHi, gives greater value as a group is more heterogeneous.

The measure of GH can be computed as follows. Let ADi be the average of the maximum and the minimum student-score in the i-th group.

$$AD_i = \frac{\max score(S_1, S_2,.., S_n) + \min score(S_1, S_2,..., S_n)}{2}$$

The measure of goodness of heterogeneity is then defined as:

$$GH_i = \frac{\max score(S_1, S_2,.., S_n) - \min score(S_1, S_2,..., S_n)}{1 + \sum_j \left| ADi - score(S_{j(i)}) \right|}$$

where S_1, S_2, ... S_n are students who belong to the group i, ADi represents the mean of the results of the best and worst student of the group i and a sum of j is the index of student group, wherein the index does not take value of the best and the worst student. If only large values of GH were pursued, it would lead to forming groups with extremely high coefficient of heterogeneity and groups with extremely low coefficient so that the final formula includes a coefficient of variance CV and then suitable algorithm is used to perform optimization for this formula. The final formula looks like this:

$$F = \omega_{GH} GH + \omega_{CV} CV$$

where GH is the sum of GHi for all groups, and CV is the coefficient of variance that represents the ratio of the standard deviation and the arithmetic mean of the results of all students, and w represents the weight. The process of optimization of this formula with the help of a Heuristiclab boils down to the definition of external tool for evaluation of solutions that are in fact based on a predefined final formula. Since this is the iterative process of finding solutions, this function is called for with each iteration. Next, we can select a suitable algorithm to optimize and adjust its parameters. In the end, it is necessary to carry out simulations with the modification of parameters (input, the algorithm and the weight of the formula) to provide a better solution whereby the operation can be performed using a suitable graphic interface of this environment.

IV. Conclusion

Given the current state of research on Project-Based Learning, what can we conclude about the relative merits of PBL as a teaching and learning method? Research on PBL implementation is largely limited to research on project-based science administered by teachers with limited prior experience with PBL. There is some evidence that students have difficulties benefiting from self-directed situations, especially in complex projects. The effectiveness of PBL as an instructional method may depend, to a greater extent than we recognize, on the incorporation of a range of supports to help students learn how to learn. There is direct and indirect evidence, both from students and teachers, that PBL is a more popular method of instruction than traditional methods. Additionally, students and teachers both believe that PBL is beneficial and effective as an instructional method.

References

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