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Project Based Learning: An Informal Way of Meaningful Science Education

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ABSTRACT

The purpose of this study was to investigate the enhancement of learning skills in students that chose science as a carrier subject using project-based learning (PBL). Eighty students (n=80) were analysed during the project designing, it's execution and finally it's presentation. Participants were grouped in two teams of 5 each such that one focusses on developing experiments and other on it's technical part. The projects were assigned to each group taking into consideration it's feasibility in school laboratory. Questionnaires that included items to measure i.e., *ease of learning subject matter, teamwork, and developing communication skills* were used to evaluate students' improvement before and after the intervention. The students were also assessed to evaluate the effectiveness of intervention on a 5-point Likert scale (1 indicating an extremely negative rating and 5 an extremely positive rating). For the data taken from the closed response questions in the grid, we calculated the average. This study revealed that PBL significantly improved ease of learning, teamwork, and communication skills in school students. PBL proved to be beneficial and effective way of science education and inculcated managerial and professional skills in school students.

Keywords: Project-based learning, sustainability, ease of learning, communication skills, teamwork

Critical thinking development provides students with the skills they need to make decisions in a rapidly changing world, discover scientific solutions to current problems, and develop into lifelong learners[1-3]. The idea of studying science is to make a difference in the world through critical thinking, innovative approaches and problem solving capabilities. In current Scenario, science has been merely reduced to mastery of content standards and preparation of students to succeed in high stake tests to achieve a numeric goal. Genuine science education should ideally arise experience, PBL works aptly and trains students how to investigate the case, pursue true observations and apply known concepts to finally design a project that aims to solve given problem [Fig. 1].

The project method grew out of the architectural and engineering education movement that began in Italy during the late sixteenth century[4]. At the beginning of the twentieth century, John Dewey's pedagogy of knowledge, "learning by doing" and Kilpatrick defined 'the project method' massively influenced the use of this approach in schools[4,5]. Today, PBL is considered to be amongst the main innovative approaches to teach science and technology in schools (K-12)[5,6]. PBL aims to provide necessary experiences to the students to connect to community and transform as agents of reform. According to Dewey's How We Think (1910/1991), the importance of reflective thought in the educational process is critical in reforming students into young investigators that can find solution to complex problems[7].

PBL deals with providing students with real-life projects and challenges related to their majors can therefore be instrumental in fostering and maintaining their interest in science and technology. Further students can be trained to connect technical

knowledge to solve a problem with emphasis on professional skills[8]. Thus, to prepare science students as per demands of industry, students should be trained to confront real life problems and brain storm a solution that is feasible with respect to accessibility of resources. Therefore, there is an urgent need of accountability in science education that can lead to dramatic shift in curriculum and instruction from rote learning to critical thinking. PBL has been used before in several different settings for effective teaching and learning[5, 9-11].

Recently, a project-based digital storytelling approach was used to improve learning performance of students. The experimental results showed that the project-based learning with digital storytelling effectively enhanced the students' science learning motivation, problem-solving competence, and learning achievement (N = 60) as compared to control group (N = 57)[12].

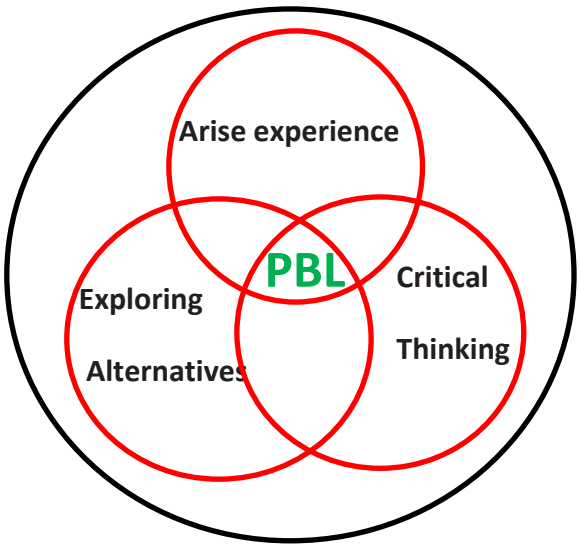

Fig. 1: PBL leads to critical thinking, arise experience in sorting problems and exploration of innovative alternatives

Aim / Objectives

Teaching critical thinking skills in the science classroom prepares students to become independent thinkers and researchers who become engaged in finding appropriate solutions to problems of the society. In schools, science teaching rarely target students' ability to think critically. This paper focusses on examining the impact of project-based learning on one's critical thinking and how it impacts cognitive and communication skills.

Implementing a progressive pedagogy such as project-based and problem-driven instruction atschool will provide an alternative approach to foster critical thinking development in the science classroom. It will provide the skill development in students need to become active participants in democratic society. The purpose of this paper is to examine the potential benefits of project-based learning.

Hypothesis

To test if students' learning outcomes were improved, the following hypotheses were developed:

- **First Hypothesis (H-1):** Using PBL will significantly improve students' teamwork.
- **Second Hypothesis (H-2):** Using PBL will significantly improve students' ease of learning the subject matter.
- **Third Hypothesis (H-3):** Using PBL will significantly improve students' communication skills.

Methodology

Eighty participants were drawn from the class XI and XII that chose science as their career subject. The students were grouped such that they have two distinct inclinations- one that focusses on developing essential experiments and other that have technical inclination towards project designing. The projects were assigned to each group taking into consideration it's feasibility in school laboratory. Two questionnaires were used to evaluate students' improvement before and after intervention. For the data from the open-ended questions (definitions, justifications, research goals or questions, findings), we used a thematic content analysis technique[13-14].

The students were assessed to evaluate the effectiveness of intervention on a 5-point Likert scale (1 indicating an extremely negative rating and 5 an extremely positive rating). For the data taken from the closed response questions in the grid, we calculated the average. The questionnaire included items to measure ease of learning subject matter, teamwork, and developing communication skills (Table 1).

Table 1: Summarising the patterns of interaction

Construct	Items
Ease of learning subject matter (EL)	PBL helped me to learn science by not mugging up but understanding the concepts. It helped me to resonate easily with those concepts of science which frustrated me earlier.
Impact on teamwork (TW)	PBL helped me to think about other's perspective of thinking, share ideas, improved interaction with team partner and arrive at meaningful decisions.
Communication skills (CS)	Improved both formal and informal communication skills.

RESULTS AND DISCUSSION

1. Effect of PBL on Partner's Team Work

Teamwork is censorious because it creates human synergy. It augments the net output of each individual of the team leading to an overall escalation in net productivity. The extent, to which the learning activity described in this paper is collaborative, in terms of situation and interaction, can be explored by considering the communications made between team partners, taking into consideration various parameters. Following parameters were considered to assess team work spirit before and after accomplishment of assigned project:

1. Frequency of communication with respect to project
2. Focus on goal and result
3. Fair share of work load
4. Organised approach
5. Enjoying the assigned task

The result of observations is given in Table 2. In Groups 2, 3 and 6 the experiment designer and technical partner started communicating, sharing workload, planning and organising assigned work better with progress of project. However, in Group 1 & 5 there was improvement in communication but coordination was not reached, possibly suggesting a lack of engagement among the partners. Group 4, 7 and 8 stands out as they kept on working as a unit without any reluctance in planning, organising and sharing of work-load with the completion of the project.

Table 2: Summarising the patterns of interaction

Group number	Observation (Team work)	
	Before PBL	**After PBL**
Group 1	Asymmetry	Cooperation
Group 2	Cooperation	Collaboration
Group 3	Cooperation	Collaboration
Group 4	Asymmetry	Collaboration
Group 5	Asymmetry	Cooperation
Group 6	Cooperation	Collaboration
Group 7	Asymmetry	Collaboration
Group 8	Asymmetry	Collaboration

2. Effect of PBL on Ease of Learning Subject Matter

A major goal of science education is to prepare students for flexible adaptation to new problems and settings. PBL has been previously documented to enhance the students' science learning motivation, problem-solving competence, and learning achievement[12]. PBL has been reported to be an effective intervention in developing social and collaborative skills not only between the partners of the same subject, but also between students from different generations and courses[15]. An intervention like PBL that enhances index of adaptive and flexible learning is desirable model of teaching and learning. It has been tested whether PBL can lead to ease of learning subject matter and better understanding of concepts.

The project timelines were so adjusted that students learn while doing the project rather than using projects as a gauge to test the extent of learning. The project was not given as an assignment rather students were presented with problems we are facing in real world and how they will work as a team to solve that problem throughout.

The result of observations is given in Table 3. All the groups showed incremental progression in terms of learning subject matter with ease without any conscious effort to memorize the content. The assessment was done on the basis of questionnaire prepared for each topic. Change in response of students was further evaluated.

Table 3: Summarising the patterns of interaction

Group number	Problem presented	Concepts Learnt	Observation (Team work)	
			Before PBL	**After PBL**
Group 1	Loss of Indian medication in this chemical world.	Kirby Bauer method, Colony Forming units, Antibiotic Sensitivity.	Learning based on remembering and cramming content.	Better understanding, analysis, and application of known facts.
Group 2	Contamination of Milk and juices with microbes- How to select best available brands.	Effect of pasteurization on microbial load of drinks, Gas produced due to fermentation puffs tetra pack, Concept of preservation-Bactericidal and bacteriostatic.	Frustrated with bulk of content to learn.	Learning by observing and inculcated trouble shooting.
Group 3	Multiple diseases can be prevented by proper handwash- Which are the most effective handwashes among several brands available in market.	Kirby Bauer method, Colony Forming units, Antibiotic Sensitivity.	Mediocre understanding of subject.	Better recapitulation of contents.
Group 4	Pollution due to cigarette butts and mosquito-borne illnesses-A common solution to both the problems.	Nicotene is toxic to mosquito & it's larvae, Fermentation of sugar produce CO_2 & CO_2 attracts mosquitoes.	Good understanding of concepts.	Learnt to apply the previous knowledge to solve assigned problems.
Group 5	Replenishment of underground water	Recycling household water waste for replenishing underground water through simple engineering	Good understanding of concepts and application of contents taught in classroom.	Learnt to apply the previous knowledge to engineer simple devices.
Group 6	Recycling waste plastic to make educational kits	Waste management for educating needy and poor.	Innovative methods were used to transform waste into useful components that can be used to educate masses	Learnt how waste can can be transformed into wealth using innovative ideas
Group 7	Study the effect of radiations on life	Non-pathogenic strains of bacterial culture were exposed to different radiation source from daily use gadgets	Good understanding of concepts.	Learnt how the biotic systems can be used to analyse the harmful effect of invisible radiations
Group 8	How to help malnutritioned, old and week Indian farmers	Simple gadgets that can help poor farmers in their day to day agricultural problems.	Mediocre understanding of concepts.	Learnt to apply the previous knowledge to solve assigned problems.

3. Effect of PBL on Communication Skills of Students

Good communication skills will help students to explain their work to people outside their field. Moreover, communication skills are one of the most important skills that employers look for in candidates. PBL provides great opportunities to students to understand the assigned work and effectively communicate their working and observations with audience leading to their transformation as better professionals in academic and industrial sector. Each Group was evaluated for given parameters both before and after PBL. Best performance and worst performance was given 5 and 0 respectively. Performance of students was measured on 0 to 5 scale for each day and average was taken in the end. Significant improvement in

confidence and communication skill was observed after PBL.

Table 4: Summarising the patterns of interaction

Sl. No.	Parameters	Best Performance	Average Performance
1	Memorizing the script	5	3
2	Pronunciation	5	3
3	Knowledge of subject	5	3
4	Coherence and cohesion	5	3
5	Vocabulary	5	3
6	Tone of voice	5	3
7	Pausing	5	3
	Total Score	**35**	**21**

Group number	Observation (Communication skill)			
	Before PBL	Std. Deviation	After PBL	Std. Deviation
Group 1	23	.77	27	.56
Group 2	26	.73	30	.84
Group 3	25	.63	30	.67
Group 4	28	.84	35	.63
Group 5	24	.84	28	.63
Group 6	25	.80	31	.60
Group 7	30	.80	34	.59
Group 8	29	.78	34	.61

Rigor

To ensure the accuracy of the data, peer review, long and continuing evaluation through in-depth, prolonged, and repeated questioning was done. Maximum variation in sampling was done to increase the dependability of data. The study was conducted under supervision of subject expert. In this research, the researcher tried to increase the credibility of the data by keeping prolonged engagement in the process of data collection.

CONCLUSION AND IMPLICATIONS OF THE STUDY

Project-Based Learning (PBL) is an innovative approach to learning that teaches a multitude of strategies critical for success in the twenty-first century. Students drive their own learning through inquiry, as well as work collaboratively to research and create projects that reflect their knowledge[15]. This study was designed to assess improvement in students' learning outcomes through using project-based learning (PBL) methodology. The findings suggest that PBL significantly improves students' ease of learning. Educators can use a project-based learning approach to facilitate students' learning. Furthermore, working together on the project improves students' teamwork skills. This suggests that PBL is an effective method which enables students to relate course materials to practice while improving their level of understanding about the subject matter.

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