



Project Based Learning Approach to Science Process Skills Chemistry Learning

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Abstract. Project based learning is a learning approach that is mediated by projects or activities. Students as learners are involved in inquiry, assessment, interpretation, synthesis and information to produce learning outcomes in various forms. As a form of student centered active teaching, project based learning is characterized by student autonomy and is carried out in practical practice through constructive inquiry, goal setting, collaboration, communication, and reflection. Project based learning has been studied in a variety of contexts, and provides students with opportunities to delve deeper into relevant learning topics. Students are designed to be more independent in building personally meaningful artifacts. The project based learning approach is useful in general and increases students' individual and collective knowledge by learning inquiry based and scientific process based skills in chemistry learning. Students engaged in project based learning develop substantive knowledge and learning are becoming increasingly important in the 21st century, teamwork, complex problem solving, the ability to apply knowledge acquired in one lesson or assignment to another. The project based learning approach engages students and teachers in finding solutions to questions about the world around them such as studying natural phenomena in science lessons. Science is a collection of knowledge about nature that is produced through a process of continuous investigation. Types of knowledge, research processes, and people in scientific fields contribute in various ways to form a unique scientific system. To achieve science learning goals and how to teach science, we describe a fun approach we call project based learning. The purpose of writing this article is to explore the possibility of a project based learning approach and to design chemistry lessons that will support and facilitate students, as well as improve the ability to integrate knowledge and improve skills in the science learning process, especially better chemistry learning. The method used includes a systematic literature review method. The results of the study show that project-based learning is more effective than traditional learning methods in science classes. The project based learning approach can be used and further developed in science subjects, especially chemistry.

Keywords: Project Based Learning · Inquiry · Teaching and Learning · Science Process Skills Chemistry Introduction

1 Introduction

Most educators around the world, both in and out of the classroom, agree that project based learning is an essential learning method. Learn the academic skills and content to develop the intellectual skills needed for future success, and the personal competencies needed to meet real life and real world challenges. Project based learning encourage students to do research that leads to real products. Projects that create stronger learning opportunities in the classroom can vary widely in topic and scope and can be undertaken across multiple grade levels.

To ensure that authentic learning is successful, teacher serve as a facilitator in the application and learning process, guiding students through many aspects of the work, including; (a) guiding students as they select projects and identify their goals, (b) supporting students as they discover and mediate relationships with mentors and experts, (c) guide students as they select projects and identify and assign tasks, (d) work with students to achieve criteria for quality work, (e) guide students as they identify a real audience for their work, (f) jump into learning when their students need to learn in another skill to complete a project. Projects that create stronger classroom learning Projects that create stronger learning opportunities in the classroom can vary widely in subject matter and scope and can be conducted at different grade levels.

Project based learning requires teaching professionals who are empowered with the necessary skills to design learning experiences that maximize students' potential. Therefore, effective science in project based learning, how to design quality learning activities requires quality professional development by teachers. Project based learning is broader and is often composed of several problems that students need for the learning process and building knowledge that has a strong meaning, challenges and motivates students.

Project based learning is an inquiry based teaching method in which students explore real world problems through individual or group projects. This teaching and learning method helps students understand why the content is useful and how to apply it. In general, research on project based learning has found that students engaged in this approach experience fact based learning that is equal to or better than those engaged in traditional forms of instruction. [1].

In short, project based learning is a model for organizing learning around projects. According to Jones, Rasmussen, and Moffitt, a project is; a complex task based on a challenging problem that involves the student's participation in a design, problem solving, decision making, or inquiry- based activity and that provides students with relatively work based opportunities to complete independently for extended periods of time a realistic product or presentation [2].

Beier et al cite Thomas to define five main characteristics, namely; project based learning: 1) The learning project is the course itself in collaboration with the student; 2) The learning project should facilitate access to the most relevant topics from the subjects covered; 3) "Activities involve constructive questioning. Students must engage in a process of inquiry, goal oriented knowledge construction, and problem solving"; 4) Learning project outcomes are flexible and students take a high degree of responsibility for their implementation; 5) The projects should be tailored to each school, taking into

account its context, intended themes, and the level of engagement students need to be involved [3].

Project based learning corresponds to the type of thinking about human nature that currently drives learning activities, and what is necessary to help students learn by understanding, retaining, and applying what they learn to situations and contexts. Project based learning aims to develop what scientists call cognitive knowledge, or “usable knowledge”, that is, knowledge that is not only memorized for exams, but has been acquired and can be used in daily life and problem solving [4].

Belwal et al, cite Utulu and Alonge who argue that project based learning builds skills and competencies: educational models such as project based learning support collaboration, inter student lifelong learning skills, technology use skills, knowledge sharing skills, and social networking. Develop life skills (teamwork, communication, etc.), exploratory processes, interdisciplinary forms of cooperation [5].

Project based learning is a student centered form of education based on three constructivist principles: a) context specific learning, b) learners actively participate in the learning process, and c) they achieve it through social interaction and sharing own target knowledge and understanding [6]. Project based learning is a model for organizing learning around projects. As defined in the teacher’s manual, a project is a design, problem solving, decision making, or inquiry activity; provides opportunities for students to make presentations.

Project based learning is consistent with current thinking of maximizing student interest and motivation. When teachers talk about project based learning, the first thing they usually look at is student engagement. Project based learning brings together many factors that have been shown to increase motivation. First, project based learning involves collaborative group efforts, and working with other students in terms of motivation. Second, Project based learning allows students to speak up, make choices and opportunities such as self expression and decision making, this is considered a very strong form of motivator among both students and adults. Third, project based learning emphasizes originality in the tasks completed and the public products that emerge from the project, and that authenticity encourages student engagement [7]. Finally, project based learning generally involves novelty in the nature of the questions posed by completed academic assignments and the context in which the project unfolds [8].

In recent years, various design models and guidelines have been created by experts and organizations. These are usually written from the teacher’s perspective. That’s why successful educators around the world use a variety of different tools and frameworks to design programs. While the “how” educators design and implement in their environments may vary, we all need to make a concerted effort to deliver a quality student experience.

Tsybulsky and Rozanov say that the professional identities of students and teachers are shaped by meaningful experiences and can be viewed in two ways; overcoming challenges while leading project based learning and engaging productively and supportively with peers cooperation [9]. This process has a positive impact on developing students’ innovative thinking, which is felt both individually and in groups, where differences in behavior lead to innovative thinking.

Blumenfeld, Fishman, Krajcik, Marx describe a project-based scientific process as follows: students are assumed to need opportunities to accumulate knowledge by solving

real-world problems, formulating improving questions, designing and conducting surveys, gathering information, interpreting and analyzing data; obtaining draw conclusions and report the results [10].

Successful implementation in the classroom depends on the teacher's ability to effectively design, motivate, support, and guide learning. A high quality project based learning framework designed to stimulate thought and dialogue about how to improve and deepen projects.

2 Teacher Preparation in Project Based Learning Applications

In a project based learning environment, teachers act as facilitators, designing activities and providing resources and advice to students. Students collect and analyze information, make discoveries, and report their findings projects are often interdisciplinary teams of various sizes and locations are working on projects. Teaching and moderation are based on different teaching goals. Project based learning provides an authentic environment where teachers can improve students' skills through collaborative learning and problem solving.

Project based learning emphasizes the importance of students thinking about what needs to be done to complete a project and taking an active role in planning and implementing project activities. The success of implementing project based learning in the classroom depends on the ability of teachers to effectively create learning scaffolds for students, motivating, supporting and guiding them in learning activities. Effective learning scaffolding in learning activities that provide a quality experience will help reduce the "cognitive load" on students [11].

A learning framework is an approach to learning supported by structured learning. Learning support can take the form of guidance, warning, encouragement, describing problems in the learning steps, providing examples, and others depending on the student's ability, so that the student can grow independently.

Using scaffolding to guide student learning: scaffolding can be considered any method or resource that helps students as learners complete a task that is more difficult than they would be able to solve on their own. Teachers, classmates, materials, and technology all act as scaffolding. Using scaffolding to support student learning is an increasingly popular approach to delivering project and design based learning environments. All mentioned that scaffolding is an important part of project based learning. Scaffolding, Grant explained, "could involve teacher student interaction, practice worksheets, peer consultation [12].

Krajcik and Shin point out that scaffolding should incorporate learning techniques. They explain that "as they engage in scientific practice, students are burdened with learning technologies that assist them in activities that are often beyond their capabilities" [13]. The use of project-based learning approaches has been suggested in the literature as an effective first approach to enabling students to reach their full potential through the development of necessary knowledge and skills In the second stage, we design and manufacture the product ourselves. Using Situational cognitive frameworks cognition theory, learning takes place in real life and is maximized when students engage with real problems [14].

Project based learning not only provides students with content, but also with fundamental skills about how students should function as adults in our society. These skills include communication and presentation skills, organization and time management skills, investigation and research skills, self-assessment and reflection skills, team participation and leadership skills, and critical thinking [15].

Performance is assessed individually, considering the quality of the manufactured product, The depth of understanding of what has been validated and its contribution to the ongoing project realization process. Project based learning empower students to reflect on their own thoughts and opinions and make decisions that affect project outcomes and the overall learning process. The final product results in a high quality, authentic product and presentation.

3 Project Based Learning Approach

Project based learning models have students, as students, confront specific problems, find solutions and work in teams on projects to solve those problems. In this model, students not only understand the content, but also the skills that enable them to function in society Skills acquired include communication and presentation skills, organization and time management skills, investigation and research skills, self-assessment and reflection skills, team participation and leadership, and critical thinking.

Project based learning is a student centered teaching method used in the classroom where students acquire in-depth knowledge and skills by solving real world challenges. Because this teaching method supports deep learning by engaging students in hands on learning activities, it can be called inquiry based learning or learning by doing. For educators, this is one of the most effective teaching methods, and for students, no learning method offers more advantages than one when it comes to active her learning.

Project based classroom learning approach teachers plan, create, facilitate, and integrate appropriate learning methods and technologies into units of study to support academic performance for students with diverse learning needs. Teachers design learning objectives and incorporate them into the program to promote the development of critical thinking, problem solving, and collaborative skills. In addition, teachers develop and implement a variety of authentic assessments to guide decision-making in learning (teaching).

Is a project based learning model suitable for learning chemistry science? A large body of literature shows that project based learning is an extremely effective method of teaching science, and by definition, project based learning engages students in a way that encourages collaboration and genuine learning. Functions and contexts have many definitions and implementations. Tamim and Grant define project based learning as a long term or short term endeavor in which students interact with each other and content takes place in the form of questions and actions to elicit answers from the students themselves [16].

4 Science Process Skills

Science is what scientists do, “Science is like biology, chemistry, and physics.” “Science is hard,” “Science is easy,” “Science is fun,” “Science is investigation.” Science is basically science and technology or the roots of science and technology. The development of science and technology is based on discoveries in the field of science. On this basis, science learning in schools must be designed to be interesting and engaging for students as students. Through interesting scientific learning, students are motivated to explore natural phenomena, and the process of creating learning activities for scientific skills, investigation and discovery, as the basis for the development of science and technology.

Science is basically a scientific field based on systematic efforts to find explanations. Abruscato, proposed several important characteristics of science, namely: 1) Science needs evidence; 2) Science is a mixture of logic and imagination; 3) Science requires explanation and prediction; 4) Scientists try to avoid bias; 5) Science is not authoritarian [17].

Science educators have identified a set of skills known as science process skills. They argue that the best way to learn science is by doing it; that students must go through a learning process, not by rote memorization; and that as students practice skills and master them personally, they can use them to develop scientific understanding [18]. Scientific process skills are considered a transferable set of skills, including procedural and reasoning skills, used by scientists from different disciplines. At the same time, processes to support inquiry based learning are identified, which are incorporated into various innovative primary and secondary school curricula. Over the years, science education experts and new curriculum programs have added additional skills deemed necessary to the science learning process.

As with science, engineering, and technological advancement, humans strive to solve problems. Technology often adapts to circumstances, while science seeks new knowledge. In science, investigative skills such as identifying problems and developing methods to test hypotheses help in problem solving. In the technical field, skills are mainly concentrated in the design process. Through technical design, there are often multiple solutions to a problem or requirement [19]. Science is a method of investigating and answering questions about the natural world by collecting and analyzing observational evidence, science based on the premise that phenomena and events in nature occur in consistent patterns that can be understood through careful and systematic study. Science is the process of generating knowledge. Scientific knowledge is both reliable and provisional. It is natural to trust scientific knowledge while recognizing that it may be updated or revised in light of new evidence or a renewed appreciation of previous evidence and knowledge. Science process skills extend knowledge to develop students’ skills and develop acquired knowledge. Akinbobola and Afolabi state that cognitive skills and problem solving skills can be achieved through scientific processing skills [20].

Applied scientific process skills are required as they indirectly engage students in research activities and allow for a comprehensive assessment of learning process skills [21]. Overall, assessment systems and learning models that apply skill assessment in scientific processes have been shown to be highly effective in improving student learning outcomes and scientific processes [22].

5 Methods

The writing of this article uses a systematic literature review approach and this article is for elaborating project-based learning in science, especially chemistry. Writing this article is also an alternative to applying learning models that can be used by students in learning natural sciences, especially chemistry. Five international journal articles obtained from <http://eric.ed.gov> as a literature review as follows; 1) Balemen, and Keskin (2018). His research results show that project based learning is 86% more effective in science education than traditional learning approaches. Project based learning was found to have large effect sizes in different subjects (physics, chemistry, biology), at different levels (primary, secondary, and tertiary) [23], 2) Nainggolan, Hutabarat, Situmorang, and Sitorus, (2020). The results of the research show that project-based learning can be used and developed in science subjects, especially chemistry [24], 3) Santyasa, Agustini, and Pratiwi, (2021). The results of the study show that learning chemistry will be more meaningful if the teacher facilitates student learning with a project based learning model [25], 4) Dai, Trung, Tiem, Hao, Anh, (2021). The results of the study show that by implementing appropriate project-based learning in chemistry classes the effectiveness of teaching is proven through experiments in general education programs that have a lot of content related to real life, which is very suitable for organizing project based teaching [26], 5) Rio, and Rodriguez, (2022). The research results It shows that the proposed project based learning helps to consolidate knowledge and improve skills within core competencies. The proposed project based learning helps consolidate knowledge and improve skills that are the core competencies of the engineering program's most time consuming and difficult subjects [27].

6 Result

From the results of the five articles above, it shows that the application of project based learning to science learning, especially chemistry, can be understood as a promising approach to improve student learning. Empirical studies of project based learning have been reviewed with a focus on student learning outcomes. The project based learning approach engages and teachers in finding solutions to students' real-world questions emphasizing the constructivist learning process. Some of the things and impacts of implementing project based learning approach are as follows.

First, engaging students in project based learning is an effective ways to help them learn critical thinking, develop as independent learners, and develop a deep understanding of specific topics. "Project based learning models are designed to exercise students' critical thinking while also focusing on questions of how phenomena exist. Likewise, the authenticity and social interaction that occurs during project based learning is essential to gaining in depth knowledge of any discipline, topic, or field, an important part of knowledge. Students who study chemistry by implementing the project based teaching method find that their classroom learning atmosphere is more satisfying and enjoyable, with more support from teachers and a more positive teacher student relationship.

Second, project based learning is interdisciplinary. This approach therefore improves overall academic success and student confidence. It's important to note that project

based learning is different from problem based learning. This project can be considered a subcategory of science education because it is used as a problem solving learning method rather than telling students what they need to know. Project based learning empowers students to participate in their own learning, forces them to ask questions and be part of the nature of scientific inquiry.

In addition to the observed increases in interest and motivation in the classroom and the cognitive skills created through project based learning, there are numerous studies reporting confidence, trust, collaboration and mastery of the world really matters, [28]. Research ranges from the general societal benefits of project based learning, to academic competency gained through practice, to the actual success of students engaging in learning through engagement and project type activities and learning [29]. Achievements observed in project based learning classrooms include cognitive, social, civic, and professional gains [30].

7 Conclusion

Based on the purpose of writing articles and a project-based learning approach in learning science, especially chemistry, it can be interpreted as follows;

Project based learning offers an engaging way of learning that keeps students engaged knowledge builder. Theory based learning, rooted in constructivism and collaborative learning, strongly supports successful acquisition. Project based learning applied by teachers in science classes, especially chemistry, can be transformative for students. By integrating decision making, complex responsibilities, cognitive concepts, and hands on activities, engaging students in a real world, collaborative, authentic, high quality educational environment that promotes the high level thinking students need to develop their abilities, the ability to perform.

Projects applied to students through inquiry based learning develop successful scientific process skills and, in particular, prepare students to face the real world of adults. Equip them and place them in the workforce, developing a confident young generation who are ready and willing to take on challenges. We believe there is research and there are certainly good reasons to apply educational theory to students and apply project based learning to students. We hope educators will find the guidelines useful for delivering effective project based learning for students as learners.

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