



Project-Based Learning Implementation in Fundamental Chemistry Courses to Meet the 21st Century Learning Target

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ABSTRAK

Penelitian ini bertujuan untuk mendeskripsikan dan menjelaskan hasil penerapan pembelajaran berbasis proyek pada pembelajaran mata kuliah Kimia Dasar I. Penelitian ini difokuskan pada pencapaian target pembelajaran Abad ke-21 meliputi: pengembangan keterampilan mahasiswa dalam berpikir kritis, berkegiatan, berkolaborasi, dan berkomunikasi. Penelitian ini dilakukan di Program Studi Pendidikan Kimia Undiksha dengan melibatkan 19 orang mahasiswa tahun pertama pada tahun akademik 2022/2023. Penelitian ini merupakan penelitian kualitatif dengan metode deskriptif. Data penelitian dikumpulkan melalui teknik observasi dan dokumentasi dan dianalisis secara interpretatif. Hasil penelitian ini menunjukkan bahwa: 1) Mahasiswa mampu membuat usulan judul proyek secara kritis dan kreatif sesuai dengan tema proyek yang diberikan; 2) Mahasiswa mampu membuat usulan dan melaksanakan proyek serta melaporkan hasil-hasilnya sesuai dengan format yang diberikan; dan 3) Mahasiswa mampu mengomunikasikan proyek secara lisan dan tertulis melalui presentasi dan penyusunan laporan proyek.

ABSTRACT

This research aimed at describing and explaining the implementation of project-based learning results in Fundamental Chemistry I course. This research was focused in achieving the 21st century learning target, namely students' critical thinking, creativity, collaboration, and communication skills. This research was conducted in Chemistry Education Study Program of Undiksha involving 19 people of first year students in academic year 2022/2023. This research was qualitative research using descriptive method. The data were collected by utilizing observation and document analysis techniques and analyzed by using interpretive analysis. The research results reveal that: 1) Students are able to propose project titles critically and creatively in accordance with the given theme; 2) Students are able to plan and implement the project as well as report the project results in accordance with the given format; and 3) Students are able to communicate the project orally and written through classroom presentation and project report writing.

1. INTRODUCTION

The implementation of independent curriculum at tertiary education has changed the orientation of learning at university level from the development of knowledge to the development of life skills. One of life skills used as the basis of learning orientation change is the 21st century learning skills involving critical thinking, creativity, collaboration, and communication skills (Mardiyah, et al. 2021; Rahayu, et al. 2022). This development is in accordance with the need of the government of Indonesia to develop students' character profile named *Profil Pelajar Pancasila* (P3) which includes faithfulness to God, morality, global diversity, team work, independency, critical thinking, and creativity (Hartono, 2022).

To achieve those development, the method of learning in tertiary education should be innovated. The learning innovation should provide opportunities for students to enhance life skills required in daily life as well as to enhance faithfulness to God and social responsibility. One of innovative learning methods which facilitate the development of the 21st century learning skills and P3 is a project-based learning. This learning method use cooperative learning principles focusing to the development of students' creativity and

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team work in solving problems. Learning process conducted in group team work provides experience to students to works in a team member having similar learning ability (Suci, 2018). Through cooperative learning, students will gain group learning experience that can be used to enhance his or her individual learning in the future. In addition, it is also stated that cooperative learning creates social interdependency among group member which builds responsibility, accountability, cohesiveness, and learning motivation to individual student in group.

Project-based learning facilitates students to develop critical thinking and creativity in choosing and organising project topic or title, work in a team with peers, and communicating project plan as well as the results, both oral and written. Project activities also provide opportunities to students to develop independency, team works, and respect individual differences as well as faithfulness to the Supreme God and morality (Mardhiya, et al. 2020).

The literature review results showed that project-based learning in Fundamental Chemistry course was rarely used. Several research results for the quality improvement of Fundamental Chemistry course were reported as follows. Juwita (2020) conducted an experiment to examine the effect of online learning towards learning achievement of students viewed from students' prior knowledge. It was found that the use of online learning increased students' achievement of 14,5 point. Silalahi (2020) conducted research and development to produce learning media based on exe-learning. The result showed that the learning media developed was feasible to be used and improved students' learning outcome. Zulfahmi and Handayani (2020) analysed students' learning difficulties in learning process and experiment. It was found that the difficulties of students' learning were on mastering basic chemical materials (50,91%), learning process (38,29%), and practical implementation (69,73%). Siregar (2020) used research and development to produce learning program based on national qualification competency of Indonesia (KKNI). The learning program developed, namely RPS and RTM, both fulfilled the requirement of KKNI. Munandar and Rumape (2021) used concept mapping learning model integrated with team group tournament type of cooperative learning. The results revealed that the average students' achievement increased from 54,14 to 75,43 and the mastering learning of student increased from 47,14% to 88,57%. Simangunson and Pane (2021) used research and development to produce discovery learning chemistry module for stoichiometry topic. The module produced was feasible, practical, and effective to be used in chemistry learning as well as increased basic chemistry learning outcome of students. Puspita, et al. (2022) utilised research and development to produce chemistry experiment module using Canva design. It was found that the module developed was favorable and suitable to be used as teaching material in online learning. Eliyarti and Rahayu (2019; 2022) conducted two different researches, namely practicum in fundamental chemistry course and students' activity reflection in online learning. The research results revealed that students had lack of self-motivation in doing practicum. It was also found that improper multitasking behavior caused negative impact for students' focus in learning.

One of research using project-based learning was conducted by Mardhiya, et al. (2020). In this research, students were given task to make video for explaining theory and solving problems in Fundamental Chemistry courses. At the end of learning process, students were asked to fulfil questionnaire about students' respond towards the given task. The research results revealed that students gave positive respond towards the given task. In addition, it was stated that through video project making students were able to apply knowledge, increase motivation, increase independency in learning, increasing team works, and increasing students' skill in using technology for learning.

The aims of the implementation of project-based learning in Fundamental Chemistry courses are: 1) to facilitate the development of students critical thinking and creativity; 2) to facilitate the development students' collaborative skill; and 3) to facilitate the development of students' communication skill. The development of these skills is viewed from students' ability in choosing and organising project. This ability reflects the critical thinking and creativity of students. The ability of students to prepare and present project proposal and project report reflects students' independency in learning and team works. The ability of student to report project results reflects students' ability to communicate orally and written.

2. METHOD

This research was qualitative research using a descriptive method (Subagia, 2022). The aims of this research were to describe and explain the implementation of project-based learning as well as the results. This research was conducted in Chemistry Education Study Program of Undiksha. The subject of this research was 19 people of first year students in academic year 2022/2023. The object of this research was students' participation in choosing and organising project, students' ability to plan and implement project, and students' ability to communicate project plan and results. These object in accordance with the 21st learning target, namely students' critical thinking, creativity, collaboration, and communication skills (Mardhiya, et al. 2020; Rahayu, et al. 2022).

This research was conducted during eight weeks or half semester. The learning process was conducted by using bilingual mode of delivery, namely English and Bahasa Indonesia. English was used to provide information and Bahasa Indonesia was used to clarify difficult concepts or procedures. Students were assigned to write all given tasks in English. The steps of learning were as follows: 1) project information, 2) project topic selection, 3) project proposal writing, 4) project proposal presentation, 5) project implementation, 6) project results presentation, and 7) project report writing.

Research data were collected by using observation and documentation techniques. Observation technique was used to observe students' participation in learning and presentation. Documentation technique was used to assess students report writing. All instruments used scale ranging from 1 to 4 which indicates insufficient (1), sufficient (2), good (3), and very good (4), respectively. The results were categorised as follows: average score $\leq 1,5$ insufficient, score 1,6 to 2,5 sufficient, 2,5 to 3,5 good, and score $\geq 3,5$ very good. In addition, qualitative data in terms of written information from project proposal and report were also collected. Data were provided descriptively and analysed by using interpretive analysis.

3. RESULT AND DISCUSSION

Results

The process learning was implemented during eight weeks or half semester in academic year 2022/2023. This learning process used project-based learning as the method of learning. The learning process was started by giving information about project theme and chemistry topics that should be integrated in the project. The project theme was "The application of chemistry in daily life." Two chemistry topics involved in this project were periodical system of elements and chemical bonds. These topics do not teach directly, but the students are asked to analyse in accordance with chemicals involved on the project. The students are asked to analyse and describe the periodical properties of elements involved in substances and to analyse chemical bond formed the compound, for example water. Water molecule has chemical formula H_2O consisted of two different atoms, namely oxygen (O) and hydrogen (H). Oxygen and hydrogen are non-metal elements which have six and one electron on the outer cell. This means that both atoms are not stable. The oxygen and hydrogen atoms are bond together in water molecule by covalent bonds.

The objectives of learning were as follows: 1) students are able to use critical thinking and creativity to choose project topic and organise project based on the given theme; 2) students are able to work collaboratively to plan dan implement project; 3) students are able to communicate project proposal and report orally and written; 4) students are able to analysis chemicals used in project; 5) students are able to describe periodical properties of element composing the chemicals, and 6) students are able to analysis chemical bonding of elements or compounds involved in the project topic. The first until the third objectives contained the development of the 21st century learning skills and the fourth until the sixth objectives contained the development of students' knowledge towards chemistry topics.

To fulfil those objectives, the learning process was conducted as follows. First, lecturer informed students about the project theme, project guideline, project proposal format, and project report format. Second, lecturer asked students to make project group involving two or three members. Third, lecturer asked each group to discuss project topic based on the given theme and to consult the topic to the lecturer to find out project appropriateness in relation to the given theme. Fourth, lecturer asked each group to write project proposal in accordance with the given format. Fifth, lecturer asked each group to present project proposal in classroom. Sixth, lecturer asked all groups to work on their own project. Seventh, lecturer asked each group to present project result in classroom. Finally, lecturer asked each group to write and collect project report in accordance with the given format.

Base on the given instruction, each group was asked to determine project topic in accordance with the given theme and write the proposal of the project. On theory, students were asked to describe the theoretical frameworks of project, materials used, chemical materials involved, the periodical properties of elements, and chemical bonds of atoms on element or compound. These facilitated students to develop understanding of the content of chemistry learning contextually.

The assessment of students' learning achievement was conducted through observation of students' activities in learning, presentation of project proposal and report, and the final project report. They were three instruments used to assess students' learning achievement, namely: 1) instrument for assessing students' participation in learning, 2) instrument for assessing students' ability to present project proposal and report, and 3) instrument for assessing project report. In addition, students' problems regarding to the understanding of chemistry contents and the use of English in writing project proposal and report were also analysed and described.

Discussion

The finding of this research is classified into six topics, namely: 1) project topics, 2) students' participation in project learning, 3) students' presentation skills, 4) students' writing quality, 5) students' problems in chemistry concepts, and 6) students' problems in English writing.

1) Project topics

There were seven groups of students proposing project topics. The topics of project proposed under the theme "The application of chemistry in daily life" were various as follows.

Table 1. Project Topics

Groups	Project Topics
I	Making Tape from Cassava
II	Making Coconut Oil
III	Making Organic Pesticides Using Local Microorganism
IV	Making Brown Sugar from Sugarcanes
V	Making Soap from Cooking Oil
VI	Making Tempe from Soybeans
VII	Making Tofu from Soybeans

Those project topics shown that students were able to think critically and creatively to select project topic based on the given theme. Although the project sound simple, to select a project topic in accordance with the project theme was not easy, particularly in relation to construct the theoretical frameworks of the project, materials used, and chemicals involved as well as to analyze periodical properties of elements and chemical bonds of atoms. Therefore, it can be concluded that project-based learning method facilitate students to enhance critical thinking skills and creativity. This finding in accordance with the finding reported by [Mardhiya et al \(2020\)](#) stated that through project learning students were able to apply knowledge, increase motivation, increase independency in learning, increasing team works, and increasing students' skill in using technology for learning.

2) Students' participation in project learning

The participation of students in project learning was assessed by using four indicators, namely: 1) team works (TW), 2) team division (TD), 3) responsibility (TR), and 4) contribution (TK). The data of students' participation in learning process were described as follows.

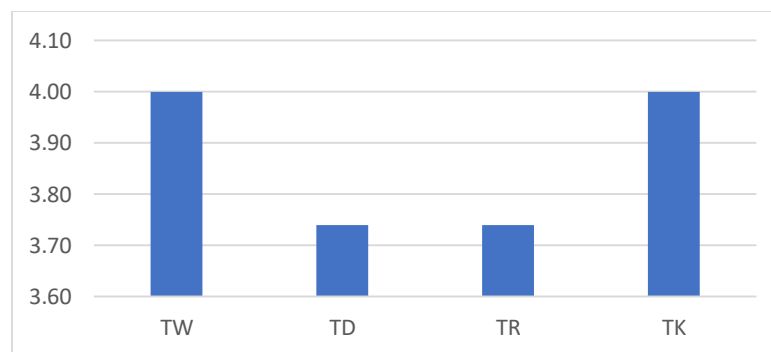


Figure 1. Participation of students in learning

Based on [Figure 1](#) above, it can be stated that the participation of students in learning was very good with average score of 3.87 out of 4.00 (maximum score). In addition, the situation in learning was very fruitful. Some students who were looked stress during previous learning, learn joyfully during working on project in a team. This indicated that project-based learning method can be used to enhance students' collaboration in learning. This can be seen from students' participation in learning, encourage students' team works, increase students' responsibility and independency in learning. This finding was also in accordance with the finding reported by [Mardhiya, et al. \(2020\)](#) when students were asked to make video project to discuss chemistry concept and solve problems.

3) Students' presentation skills

The ability of students to communicate orally were assessed based on proposal and project report presentations. This ability is viewed from four indicators, namely: 1) presentation opening and closing (PC), 2) presentation organisation (PO), 3) presentation media (PM), and 4) language quality (LQ). Data of students' presentation ability were described as follows.

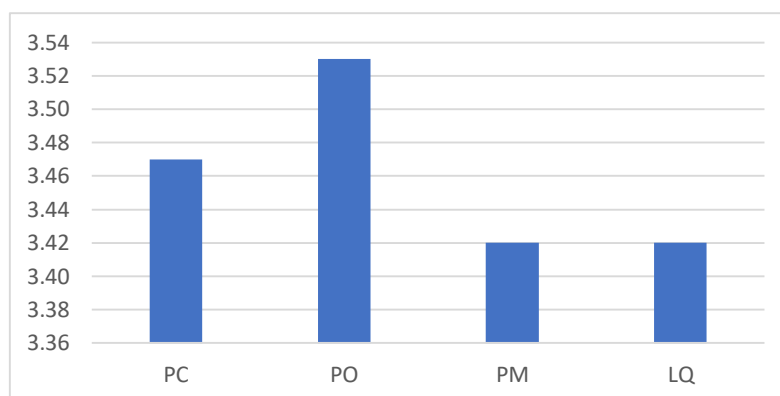


Figure 2. Presentation skills of students

Based on Figure 2 above, it can be mentioned that students have good ability to communicate orally with average score 3.46 out of 4.00 (maximum score). Students have very good ability to say greeting to the audience at beginning and ending presentation as well as organising learning materials. In contrast, they still had weaknesses in developing presentation media and pronouncing scientific phrases (scientific terms). In general, project-based learning method enhances students' communication skills as required in the 21st century learning (Suci, 2018).

4) Students' writing quality

The ability of students to write project report was assessed from the quality of proposal and project report writing. The quality of students writing was viewed from writing format and grammar. The writing format was seen from format completeness and content. The assessment of grammar was focused on the writing of project procedures, both in proposal and report.

The results shown that students were able to write proposal and project report in accordance with the given format. Students' proposal project consisted of title, authors identity, objectives, theoretical frameworks, materials and equipment, procedures, schedules, and references. The project report was added another two aspects, namely results and discussion. Students' project proposal and report writing shown several mistakes in terms of writing chemical formula, chemical bonds, and permanent and temporary charge concepts. Those mistakes were caused by lack students' understanding of chemistry concepts as also found out by Priliyanti, et al. (2021). Examples of students' error in writing were described as follows.

Tabel 1. Examples of Content Mistakes

Component	Wrong	Right
Writing of chemical formulas	<ol style="list-style-type: none"> 1. CH3COOH 2. H2O 3. O2 	<ol style="list-style-type: none"> 1. CH₃(CH₂)₆COOH 2. H₂O 3. O₂
Writing of chemical bonds	Do not write the type of chemical bonds among atoms in glucose (C ₆ H ₁₂ O ₆) and water (H ₂ O).	The glucose (C ₆ H ₁₂ O ₆) and water (H ₂ O) molecules have covalent bonds.
Writing temporary or permanent charge of molecules	The charge of H and O atoms in water molecule is written permanently using + and -.	The charge of H and O atoms in water molecule should be written temporary using symbol δ+ and δ-.

In general, students used appropriate grammar in writing, particularly in writing procedures both in proposal and report. In writing procedure in proposal project, students used imperative sentences, while

in writing project report they used passive sentences. Examples of students writing for proposal and report project procedure were described as follows.

Tabel 2. Example of Procedures Writing

Project Proposal Procedures	Project Report Procedures
1. Soak the active carbon with cooking oil for 24 hours.	1. The active carbon was soaked with cooking oil for 24 hours.
2. Strain the oil.	2. The oil was strained.
3. Mix NaOH into the water.	3. NaOH was mixed into the water.
4. Mix NaOH solution with oil and stir until become thick.	4. NaOH solution was mixed with oil and stirred until becomes thick.
5. Add fragrance oil.	5. Fragrance oil was added.
6. Pour the batter into the mold and wait 24 hours.	6. The batter was poured into the mold and waited 24 hours
7. Take the soak from the mold.	7. The soak was taken from the mold.
8. Put the soak in an open space for 1-4 weeks.	8. The soak was put in open space for 1-4 weeks.

5) Students' problems in chemistry concepts

In understanding chemistry concepts, students had several problems. These problems were writing charge of chemical species (ions), writing unit for volume, and writing chemical formula. On students' writing, it was found that several students write chemical species wrongly, for example NH_3^+ . This indicates that student has wrong concept about ion because NH_3 is a molecule and has no charge. The charging species must be NH_4^+ for ammonium ion. A writing for volume unit used symbol small letter (ml). This writing was incorrect because the volume unit should be written by using symbol small letter for 'm' and capital letter for 'L' (mL). Some chemical formulas were written wrongly, for example CO_2 , H_2O , O_2 , and CH_3COOH . This could be considered as common mistake for many students. However, this mistake should be corrected as soon as possible because the writing of chemical formula should follow an international agreement as stated by IUPAC (International Union of Pure and Applied Chemistry). Based on IUPAC nomenclature, index in chemical formula should be written as subscript. Therefore, for the above chemicals, the chemical formula should be written CO_2 , H_2O , O_2 , and CH_3COOH . This finding was in lined with students' difficulties in chemistry learning reported by [Zulfahmi and Handayani \(2020\)](#). It was found that the difficulties of students' learning were on mastering basic chemical materials (50,91%), learning process (38,29%), and practical implementation (69,73%).

6) Students' problems in English writing

Student problem in English writing include: choice of words, writing passive sentence, and writing clause. The first mistake made by students in choosing word in writing an experiment procedure was the use of verb or noun. For example, "Boiling 200 mL water" or "Boil 200 mL water." In this case, they should use the words 'boil' as verb, not 'boiling' as noun because the sentence used in writing experiment procedure should be in the form of imperative sentence. The second mistake was the use of passive sentence in writing experiment procedure for reporting. In writing passive sentence many students forget to include 'to be' after the subject. For example, "Water and thick coconut milk separated using tablespoon. The correct sentence must be "Water and thick coconut milk was separated using tablespoon. The third mistake was the writing of clauses. The clause could be written in two ways, namely using to be or auxiliary verb after the word which, that, or who, and without writing to be or auxiliary verb. For example, the students wrote "Tempe is a food which made of soybeans." The correct one was "Tempe is a food which is made of soybeans," or "Tempe is a food made of soybeans. These typical mistakes could be considered as English common mistake made by students coming from nonspeaking English countries. This was happened due to the differences of language structure (grammar). [Tambunsaribu and Galingsing \(2021\)](#) mentioned that grammar can be seen as the major factor (66%) contributing the difficulties of student in English writing.

4. CONCLUSION

The use of project-based learning method in Fundamental Chemistry subject facilitates students to enhance the 21st century learning competency. The critical thinking and creativity of students are challenge through activities to choose project topic and proposal under the given theme. Students' collaboration skill is developed through group work in preparing, implementing, and reporting project. The communication skill

of students is enhanced, both in terms of oral presentation and writing. Since the subject matter is taught in bilingual, the presentation provides opportunity for student to enhance their speaking skill. Based on the research finding, it is recommended to use project-based learning method to facilitate students to learn. This method meets the requirement of the 21st century learning and make students to learn joyfully.

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