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Differentiated Project Based Learning to Improve Collaboration Skills and Cognitive Learning Outcomes of High School Students on Colloidal System Material

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Abstract: This research is a Classroom Action Research (CAR) using two cycles, conducted in class XI IPA 1 SMAN 1 Seyegan, Sleman, Yogyakarta which amounted to 36 students. The purpose of CAR is to improve collaboration skills and cognitive learning outcomes of students in class XI IPA 1 at SMA Negeri 1 Seyegan using the Project Based Learning (PjBL) learning model with process and product differentiation. Based on the results of the study, this learning model was able to improve the collaboration skills of students of class XI IPA 1 significantly, namely 17.11%. This learning model is also able to improve the cognitive learning outcomes of students in terms of various aspects, namely the average value, the lowest value, the highest value, the number of students who are complete, and the percentage of classical learning completeness. The average posttest score an increase of 29.38%. Classical learning completeness during the posttest also increased significantly from 22.22% in cycle I to 77.78% in cycle II. This proves that the PjBL learning model with process and product differentiation is able to improve collaboration skills and cognitive learning outcomes of students in class XI IPA 1 at SMAN 1 Seyegan on colloidal system material.

Keywords: Cognitive Learning Outcomes; Collaboration Skills; Colloidal Systems; Differentiation; Pjbl

Introduction

Various efforts to improve learning models that are tailored to the characteristics of the material, technological developments, and the diverse potential of students to optimize their quality are still being developed. The learning model used is certainly adapted to the material taught according to the characteristics of a particular material (Andriani et al., 2017). Chemistry learning at the high school level should be able to encourage the application of the knowledge learned to solve problems in everyday life by prioritizing learning that focuses on students (Fahrezi et al., 2020; Santyasa et al., 2021; Sukma & Ibrahim, 2016, Sweeney et al 2020). In some cases, students are asked to practice solving various problems independently at home, without being directed to complete projects that are relevant to the learning material. As a result, learners only know a concept superficially, but find it difficult to apply the concept in solving the given problem (Experenza et al., 2019; Irawati et al., 2022; Khoiriyah et al., 2021).

Technological developments are needed in learning, in addition to being used to support 21st century skills, various computer-based technologies also provide breadth for students to adopt various knowledge that supports learning (Mufiqon, 2012; Murdani et al., 2023). The use of interesting and varied media will be able to streamline the learning process, so it is hoped that teachers as educators will be able to utilize technology to support the success of students (Bedin et al, 2023; Uno., 2021; Widianto, 2021). Various efforts to improve learning do not only focus on the learning model used, the characteristics of the material, and technological developments, but recognizing the

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diverse potential of students is also an important component in optimizing the quality of learning. In accordance with Ki Hajar Dewantara's thinking, education adheres to the principle of independence and must be adapted to the nature and times of the learners (Irawati et al., 2022; Pangestu & Rochmat, 2021; Suparlan, 2015).

Based on the results of the Even Semester Midterm Assessment (ESMA) in 2023, class XI IPA 1 at SMA Negeri 1 Seyegan, Sleman Regency, Yogyakarta Special Region is the class with the lowest average score among the other three classes. Based on observations in all classes starting the new school year, July 11, 2022, every learning activity in class XI IPA 1 is actually almost the same as other classes, it just looks less active when given a joint project or asked to discuss in groups. The difference will be more visible in the dominant material that has a lot of memorization, such as hydrocarbons and petroleum taught in the odd semester of 2022. This fact is corroborated through discussions with other subject teachers in the same class.

Colloidal system material based on the 2013 curriculum chemistry syllabus is found in KD 3.14 and 4.14. The content of this material is dominantly memorized which is taught in the even semester of 2023. Basically, colloidal system material is closely related to our daily lives, so the purpose of this study is to bridge the various limitations found in class XI IPA 1 by applying a differentiated Project Based Learning (PjBL) learning model that accommodates the diverse potential of students (Purnawanto, 2023; Tomlinson, 2017). Differentiated learning emerged as an approach that is believed to increase creative behavior (Asriadi et al., 2023; Anazifa et al., 2017; Santos et al, 2018; Tomlinson et al., 2008).

The PjBL Learning Model is a learning model that involves students directly in the learning process to solve a problem given during learning (Ananda et al., 2023; Purwaningsih et al., 2020; Umar, 2016). The PjBL steps taken in this study are: making essential questions; making project design; preparing a schedule/timeline; monitoring the project; evaluating the project/assessing the results; and reflecting on the project that has been carried out during learning.

Four components in differentiated learning that are believed to have a strong influence in supporting successful learning are content, process, product, and learning environment differentiation (Herwina, 2021; Marlina, 2019). Based on various considerations, the differentiation chosen in the research is process and product differentiation. Both were chosen with the aim of further optimizing learner collaboration in the learning process. Process differentiated learning can be done independently or in groups.

In this study, process differentiation was carried out when students in groups collaborated to express ideas and ideas in designing projects using Google Jamboard. Collaboration is the activity of working together with a group of people to realize a common goal (Hansen, 2009; Hesse, 2015). Collaborative activities are expected to foster a culture of participation, individual expression, group responsibility, and increase creativity (Broderick, 2014). Product differentiated learning relates to how learners are able to demonstrate what has been learned in the learning process. In product differentiated learning, learners' learning styles have a very important role. The products produced adjust the skills and interests of each learner (Marlina, 2019). In this research, product differentiated learning is realized when pouring ideas and ideas that have been designed in groups into creative products with the theme of colloidal systems that are useful in everyday life. The resulting products will be exhibited at the market day event which is held in conjunction with the school class meeting activities.

Learning colloidal systems using a PjBL model with differentiation content will be more meaningful if supported by a daily approach and integrating technology in it. Collaborative integration of technology can be implemented by students to join with other students, be active in learning, thus facilitating the achievement of learning objectives (Kamulung, 2017). In learning the Colloid System by applying the PjBL model with differentiation content, it is expected to improve collaboration skills and cognitive learning outcomes of students in class XI IPA 1 at SMA Negeri 1 Seyegan, Sleman Regency, Yogyakarta Special Region.

Method

This research is a descriptive qualitative Classroom Action Research (CAR). The subjects in this study were all students of class XI IPA 1 at SMA Negeri 1 Seyegan, Sleman Regency, Yogyakarta Special Region, totaling 36 people (16 male students and 20 female students). This CAR uses 2 cycles which refer to the Kemmis & Taggart design (Wijaya et al., 2021). An illustration of the two cycles in the study is in Figure 1.

Based on the stages of CAR in 2 cycles, it consists of planning, implementation, observation, and reflection. In the planning stage, the activities carried out include preparation: Learning Implementation Plan (LIP) and Learner Worksheet (LW) according to the PjBL syntax with differentiation, collaboration skills observation sheet, question grids, and pretest and posttest questions in each cycle. The observation sheet and questions used have been theoretically validated by experts. The implementation stage was carried out along with observation and data collection activities. In the implementation stage, PjBL with differentiation used is process and product differentiation. Process differentiation learning is carried out by integrating technology through the use of learning.id accounts that come from government assistance for students to collaborate together using Google Jamboard. The stages of this activity were assisted by observers who were colleagues of researchers at SMA Negeri 1 Seyegan, Sleman Regency, Yogyakarta Special Region.

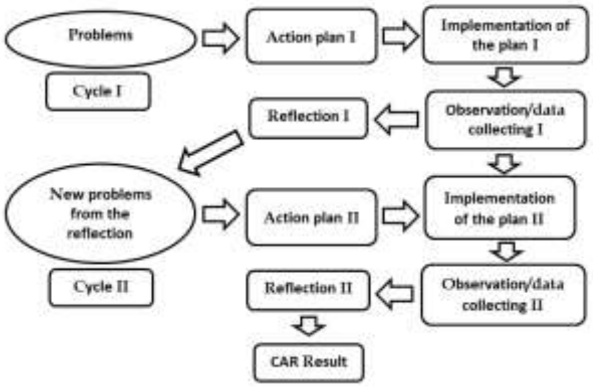

Figure 1. Stages of CAR in 2 Cycles

At the end of each cycle, reflection activities were carried out. At this stage, researchers together with observers review and analyze the results of observations and the results of cognitive tests that have been carried out in order to get a picture of the results of the study as a guide for further actions to be taken in the study.

Colloid System Classroom Action Research was carried out in the even semester of the 2022/2023 school year, namely on May 8 to 29, 2023, and a work market day which was held on June 14, 2023. Coverage of Colloid System material in research based on KD 3.14 includes properties, types, and uses of colloidal systems in everyday life, and KD 4.14 includes making colloidal systems.

The techniques used to collect data in the study were observation and tests. The observation sheet was used to measure students' collaboration skills during the learning process. PjBL learning with process and product differentiation is designed in groups that are arranged based on readiness at the beginning of learning using circles of understanding. Each learner in his group collaborates to complete the tasks contained in the LW that have been provided. Observation is measured using a non-test instrument, namely an observation sheet equipped with an assessment rubric. This assessment rubric is filled in by the observer at each meeting. Observers were first briefed before making observations. While the test is used to measure the cognitive learning outcomes of students before and after treatment. The test was carried out four times, namely twice the pretest and twice the posttest. In each cycle, pretests and posttests are always carried out.

For the observation sheet, indicators of collaboration skills were synthesized from 10 sources, namely 9 journals and 1 unpublished thesis. The results of the synthesis of collaboration skills are in Table 1.

Table 1. Synthesis Results of Collaboration Skills

Aspect	Indicator
Communication Skill	Ability to speak, ask questions, express opinions, and communicate results.
Cooperation Skill	Ability to provide assistance and contribute to the group.
Task Completion Skill	Ability to help each other in completing tasks on time.
Skill of respecting others	Ability to respect others and accept constructive criticism from others.

Each indicator used in the observation uses a Likert scale of 1 to 3 with the following conditions. (1) learners have a lack of collaboration skills according to related indicators; (2) learners have a moderate level of collaboration skills according to related indicators; and (3) learners have good collaboration skills according to related indicators.

The data analysis technique in this study was carried out descriptively qualitative. CAR is declared successful if there is a significant increase in collaboration skills and cognitive learning outcomes of students in class XI IPA 1 at SMA Negeri 1 Seyegan on colloidal system material from cycle I to cycle II.

Result and Discussion

The results of observations of collaboration skills that have been carried out by observers during CAR are in Table 2. Based on the observation of collaboration skills, an increase in all indicators (I1 to I4) was obtained significantly from cycle I to cycle II by 52 or an increase of 17.11%. This shows that PjBL learning with process and product differentiation on colloidal system material can significantly improve the collaboration skills of XI MIPA 1 class students at SMA Negeri 1 Seyegan. The cognitive learning outcomes that have been carried out in cycle I in the study are listed in Table 3.

Table 2. Observation Results of Collaboration Skills

Total Observation Score of Cycle I				Total Observation Score of Cycle II			
I1	I2	I3	I4	I1	I2	I3	I4
80	81	72	71	92	91	84	89
Total observation score of cycle I: 304				Total observation score of cycle II: 356			

Description:

- I1 : Ability to speak, ask questions, express opinions, and communicate results.
- I2 : Ability to provide assistance and contribute to the group.
- I3 : Ability to help each other complete tasks on time.
- I4 : Ability to respect others and accept constructive criticism from others.

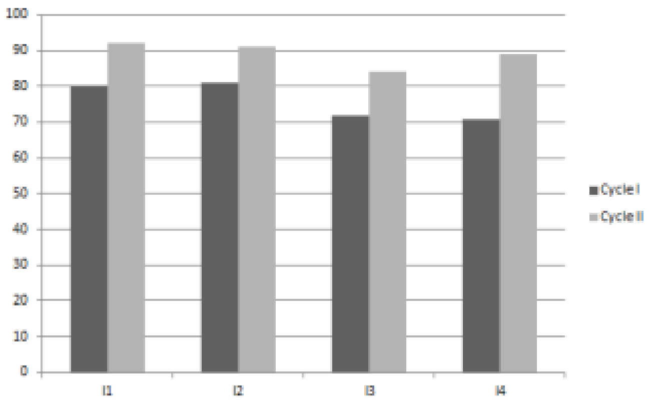

Figure 2. Comparison of Achievement of Collaboration Skills Cycle I with Cycle II

Table 3. Cognitive Learning Outcomes Cycle I

Aspect	Pretest	Posttest
Mean score	53,96	63,82
The lowest score	35,00	45,00
The highest score	80,00	87,50
Number of learners passing the minimum score	3	8
Classical learning completeness (%)	8,33	22,22

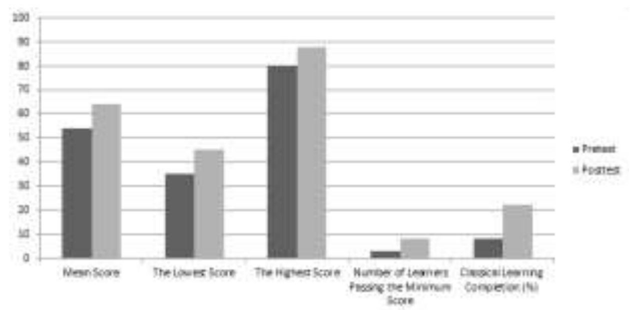

Figure 3. Comparison of Achievement of Cognitive Outcomes Pretest with Posttest in Cycle I

A comparison of the achievement of collaboration skills in cycle I with cycle II is shown in Figure 2. Comparison of the achievement of cognitive results of pretest with posttest in cycle I is shown in Figure 3.

Based on the comparison of the achievement of pretest and posttest cognitive results in cycle I, it was found that each aspect did show an increase. However, classical learning completeness still did not meet the criteria, which was 75%. Based on the results of the reflection that has been carried out with the observer, this is because the researcher is still not optimal in applying PjBL with differentiation content and does not link the learning material with everyday life. In cycle I, students were also not accustomed to expressing ideas and ideas and expressing these ideas and ideas collaboratively. Based on this, CAR must be continued to cycle II with various improvements according to the notes of reflection results that have been discussed with observers.

The cognitive learning outcomes that have been carried out in cycle II in the study are in Table 4. Comparison of the achievement of cognitive results of pretest with posttest in cycle II is in Figure 4.

Table 4. Cognitive Learning Outcomes Cycle II

Aspect	Pretest	Posttest
Mean score	58.96	82.57
The lowest score	40.00	55.00
The highest score	85.00	97.50
Number of learners passing the minimum score	7	28
Classical learning completeness (%)	19.44	77.78

Based on the comparison of the achievement of pretest and posttest cognitive results in cycle II, it is found that each aspect has shown a significant increase, especially the completeness of cognitive learning outcomes at the time of the posttest has met the criteria above 75%, reaching 77.78%. This is because in cycle II researchers have tried to apply PjBL with differentiation and relate learning to everyday life. At the end of cycle II learning, a work title/market day was also held, so that students were more eager to follow each stage of learning. The following is documentation of market day activities on Figure 5.

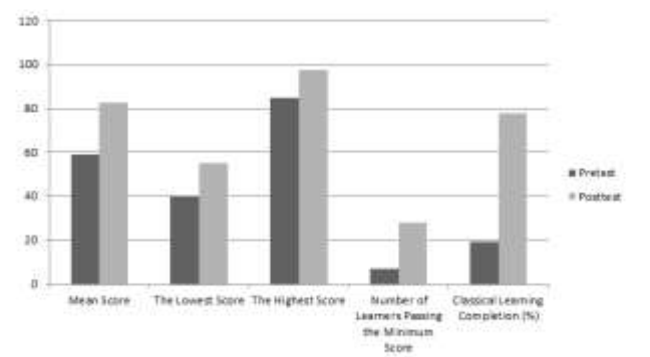

Figure 4. Comparison of Achievement of Cognitive Outcomes Pretest with Posttest in Cycle II

Figure 5. Market Day Activities

Based on the results of observations and cognitive learning outcomes (pretest and posttest) in cycles I and II, it proves that the PjBL learning model with differentiation of processes and products is able to improve collaboration skills and cognitive learning outcomes of students in class XI IPA 1 at SMA Negeri 1 Seyegan, Sleman Regency, Yogyakarta Special Region on colloidal system material.

Conclusion

Based on the research that has been carried out in cycles I and II along with the discussion, it can be stated that learning the colloid system using the PjBL model with process and product differentiation is able to improve the collaboration skills of students in class XI IPA 1 at SMA Negeri 1 Seyegan significantly, namely 17.11%. This learning model is also able to significantly improve the cognitive learning outcomes of students, in terms of various aspects, namely the average value, the lowest value, the highest value, the number of students who are complete, and the percentage of classical learning completeness. The average posttest score increased from 63.82 in cycle I to 82.57 in cycle II, or an increase of 29.38%. Classical learning completeness during the posttest also increased significantly from 22.22% in cycle I to 77.78% in cycle II. The various results of this study prove that the PjBL learning model with process and product differentiation is able to improve collaboration skills and cognitive learning outcomes of XI IPA 1 class students at SMA Negeri 1 Seyegan, Sleman Regency, Yogyakarta Special Region on colloidal system material.

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Author Contributions

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Conflicts of Interest

The authors consciously declare that this research was conducted without any pressure from any party, including pressure due to commercial, financial, and or political interests that could potentially cause conflicts of interest.

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