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Application of Online Project-Based Worksheets in the Utilization of Wood Sawdust as Adsorbents in Industri Liquid Waste Treatment

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ABSTRACT

This study aims to analyze performance and students' higher-order thinking skills after implementing project-based worksheets on sawdust as an adsorbent in industrial waste treatment. The research method used is a pre-experiment with a one-shot case study design. The subjects of this study were chemical education students at UIN Sunan Gunung Djati Bandung who took the chemical separation course. The instruments used are learning descriptions, worksheets, and higher-order thinking skills. The results showed that the average value of student performance in completing the bold project-based worksheets was 92.6, with an outstanding category. The highest average score achieved was in phase 3 of designing the project, with 96.5, an exceptional category. In the excellent category, the lowest average score in phase 4 of compiling product drafts/prototypes was 83.75. The results of students' higher-order thinking skills obtained an average value of 82.2, with an outstanding category. Thus, the bold application of project-based worksheets on using sawdust as an adsorbent in industrial wastewater treatment can develop high-order thinking skills in students.

INTRODUCTION

The chemical learning process assisted by practicum activities will make learning more remembered by students, and they will be able to develop knowledge, skills and scientific attitudes (Saraswati & Mertayasa, 2020). This learning emphasizes providing direct experience to develop competencies so that students can understand the natural environment scientifically (Sukmawardani et al., 2022). In this case, a supporting instrument is needed so that the practicum implementation runs well and learning indicators are achieved. The lack of facilities and infrastructure will hinder the learning process. This problem could impact teaching materials needed to direct students in practicum activities, including a worksheet (Wahyuni et al., 2018).

A study from Widayanti et al. (2018) described the assessment of PjBL-based practicum worksheets using a mixed method, namely small group trials (80.6%) and field tests (81.5%) with the exciting category, which proves that PjBL-based practicum worksheets can be used as an exciting learning medium for students to work on. Similarly, the results of TIMSS (Trends in Mathematics and Science Study) show that students in Indonesia still have low levels of higher-level thinking abilities. This occurs because students lack the stimulation to improve their higher-level thinking abilities (Rofiah et al., 2013). Other research states that the ability to evaluate and create is good. Therefore, it can be concluded that the current needs of students are oriented towards higher-level thinking abilities (Subarkah, 2017). Therefore, the worksheets are used in the practicum process in conventional worksheets or modules that do not yet have

syntax or learning stages and do not make students active in learning. Therefore, there needs to be a worksheet that can direct students during practicum activities. Project-based worksheets are one alternative because they provide instructions for planning and designing a product (Widiyani, 2021). However, the manufacture of worksheets must be packaged attractively. Along with the development of technology and efforts to reduce paper waste, there needs to be an innovation in using worksheets, namely by using Google Forms. With Google Forms, it will be easier to monitor students' performance when working on worksheets, and it has several features that can make students more disciplined (Lukum & Paramata, 2015).

In the chemistry practicum of separation, students need to analyse problems and design projects to design procedures to be carried out. Chemistry practicum activities focus more on honing chemical concepts and experimental principles, which can develop high-level thinking abilities. The practicum process cannot facilitate high-level thinking skills in producing an experimental product, so students still lack curiosity and the ability to express opinions. High-level thinking is one of the factors needed in education because it can guide students in competing with the global world. Educators must be able to develop high-level thinking abilities for students in all subjects, including chemistry. The process can help students develop high-level thinking skills that lead them to solve environmental problems such as industrial liquid waste treatment (Rahayu & Firmansyah, 2018).

It is necessary to treat waste before it is discharged into receiving water bodies so that it does not pollute the environment. In this case, the waste contains many kinds of heavy metals which are toxic to the environment (Sukmawardani & Aminah, 2019). Before disposing of waste to the community, many ways can be done, namely with the help of adsorbents. Adsorbents can be used to lower the level of harmful waste parameters. Dust wood saws can be adsorbents that absorb heavy metals and balance waste measurement parameters following environmental quality standards (Arini & Aminah, 2020).

This research is expected to increase student activities in learning and understanding the material through the syntax/stage in the project-based worksheets, develop high-level thinking skills and make it easier for students to understand the concept of chemistry, analyse the benefits of chemistry for life, and increase experience in treating industrial liquid waste.

METHODS

Research Design

The research method used in this research is pre-experiment with a one-shot case study design, which refers to the Ismail research method book (2018). A comparison group does not accompany this research method. It is not given a pretest question or no initial test while finding out the effect of other treatments will be obtained without moving other factors. This research design can lead researchers to apply new learning products like worksheets. This study has three stages of research procedures, namely 1) Preparation Stage, At this stage, an online project-based worksheet analysis is carried out, preliminary studies, material analysis, analysis of separation chemistry practical material in the oxidation-reduction titration module, determining the title, objectives and benefits of research, preparing instruments and validating worksheet until worksheets are suitable to use. 2) Implementation Stage: The execution or implementation of the online project-based worksheets created previously is carried out. The application of the worksheet is carried out in practical learning activities in the laboratory. 3) Final Stage: This stage usually includes data collection, processing, and conclusions.

Research Target

The subject of this research is a student of Chemistry Education, semester VI of UIN Sunan Gunung Djati Bandung, in the Separation Chemistry course. Students in groups conducted an oxidation-reduction titration experiment using the permanganometric method regarding

sawdust as an adsorbent in treating industrial liquid waste. Per the instructions for implementing practicum in the laboratory, practicum activities are carried out by completing project-based worksheets online with a group of friends.

Research Data

In this study, the data obtained is qualitative and quantitative. Qualitative research is obtained through a scientific process in order to obtain systematic data based on the results of observations carried out by researchers, then described and interpreted based on the data obtained, while quantitative research instruments in the data are in the form of numbers or numbers that are analysed using value score techniques determined based on project-based worksheets grids.

Research Instruments

The instrument utilized in this research is observations and student worksheets. Student worksheets cover all student activities and students' ability to do project-based worksheets online.

Data Analysis

The data analysis refers to the assessment rubric and worksheet grids that measure students' ability to complete the stages of worksheet work. The percentage results are analyzed and poured into qualitative data as in Table 1.

Table 1. Interpretation of assessment

Average Value	Interpretation
80-100	Very Good
66-79	Good
56-65	Enough
40-45	Less
30-39	Fail

Data analysis in worksheets is also used to analyze student activities during practicum based on measured high-level thinking skills. The analysis results are then adjusted to the criteria for the assessment results on the question. According to Bloom's Taxonomy, higher-level thinking abilities include the ability to analyze (C4), the ability to evaluate (C5), and the ability to create (C6). The acquisition of the value is obtained from each individual whose score is scored and presented. Data analysis will be calculated with the formula :

$$NP = \frac{R}{SM} \times 100$$

The percentage results are analyzed and poured into qualitative data, as in Table 2.

Table 2.Interpretation of assessment of higher order thinking skills

Average Value	Interpretation
80-100	Very Good
66-79	Good
56-65	Enough
40-45	Less
30-39	Fail

RESULTS AND DISCUSSION

Student Performance When Applying Worksheets

Research on applying project-based worksheets online was conducted with a reduction-oxidation titration practicum activity of the permanganometric method by working on worksheets in groups. Worksheet work is carried out during two meetings, with filling worksheets simultaneously starting when the practicum starts and worksheet work ending when the practicum ends. Each meeting is filled with three stages of activities, namely preliminary activities, core activities, and closing activities. The stages of working on worksheets are divided into five phases, namely 1) Problem identification, 2) Making project design, 3) Carrying out research, 4) Compiling product drafts/prototypes, and 5) Finalization and publication.

The worksheet work is done through the Google form, and a timeframe is given for each phase of the worksheet. Students become more disciplined and can do all the questions without missing anything. Students with excellent performance carry out each phase of the worksheets; this is evidenced by the results of the worksheet work for each phase by students who get scores above the average. The results of the worksheet work in each phase can be seen in Table 3.

Table 3. Recapitulation of each group's scores in completing project-based worksheets online

Group	Stages in Project-Based Worksheet					AVR	Interpretation
	Fase 1	Fase 2	Fase 3	Fase 4	Fase 5		
1A	94	95	86	85	100	92	Very Good
2A	94	97	86	75	80	86,4	Very Good
3A	88	95	100	95	100	95,6	Very Good
4A	88	97	100	85	80	90	Very Good
5A	88	97	100	80	100	93	Very Good
6A	94	93	100	90	100	95,4	Very Good
7A	100	100	100	100	80	96	Very Good
8A	100	97	100	90	100	97,4	Very Good
1B	88	90	86	95	80	87,8	Very Good
2B	94	93	86	65	100	87,6	Very Good
3B	94	95	100	75	100	92,8	Very Good
4B	94	95	100	75	100	92,8	Very Good
5B	100	100	100	85	80	93	Very Good
6B	94	97	100	70	100	92,2	Very Good
7B	94	100	100	85	100	95,8	Very Good
8B	100	100	100	90	80	94	Very Good
AVR	94	96,3	96,5	83,75	92,5	92,6	Very Good

Students' higher-order thinking skills after implementing online project-based worksheets

High-level thinking skills are given to students after completing the practicum and after finishing presenting worksheets. Students fill in the question of high-level thinking skills regarding the use of sawdust as an adsorbent in industrial liquid waste treatment. Question-filling is done online using the Google form link by each student and is a closed book.

This question aims to develop students' high-level thinking skills through C4, C5, and C6 questions and measure the extent to which students have high-level thinking skills after implementing project-based worksheets online. Table 4 presents the value of students working on high-level thinking skills.

Table 4.Recapitulation of the average score for higher-order thinking skills for each item

Cognitive Level	Higher Order Thinking Ability Indicator	No Question	Average	Interpretation
C4 : Analyze	Students can correctly analyse the characteristics of adsorbents for treating industrial wastewater based on their purity level.	1	73	Good
	Based on the data in the graph, students can correctly analyze the effect of mass on the adsorbent absorption process.	2	76	Good
C5 : Evaluate	Students can check the COD content in waste based on the data known in the questions correctly and correctly.	3	84	Very Good
	Students can correctly compare the characteristics of the two types of waste parameter measurements based on the data in the table.	4a	96	Very Good
		4b	84	Very Good
C6 : Create	Students can create a procedure for activating wood sawdust to be properly used as an adsorbent.	5	80	Very Good
Average			82,2	Very Good

The table shows the results of working on high-level thinking skills. Five questions were developed based on indicators of high-level thinking ability using sawdust as an adsorbent in industrial liquid waste treatment. The following recapitulates the value of high-level thinking skills based on the average of each cognitive level presented in Table 5.

Table 5. Recapitulation of the average scores for higher-order thinking skills at each cognitive level

Cognitive Level	No Question	Skor	AVR	Interpretation
C4 : Analyze	1	73	74,5	Good
	2	76		
C5 : Evaluate	3	84	88	Very Good
	4a	96		
	4b	84		
C6 : Create	5	80	80	Very Good
Average			80,8	Very Good

Overall, students completed project-based worksheets online and filled in high-level thinking skills. The results of students' high-level thinking skills are categorized very well, with an average score of 80.8. Table 6 recapitulates the connectedness between project-based worksheets and high-level thinking skills.

Table 6. Project-based worksheets stage recapitulation with high-order thinking skill ability indicators

No	Project-based Worksheets Phase	Skor	High Level of Thinking Ability	Skor
1.	Phase 1: Designing a project	94	C4: Analyze	74,5
2.	Phase 2: Make a project design	96,3	C4: Analyze	74,5
3.	Phase 3: Carry out research	96,5	C6: Create	80

No	Project-based Worksheets Phase	Skor	High Level of Thinking Ability	Skor
4.	Fase 4: Compiling product draft/prototype	83,75	C4: Analyze	74,5
			C5: Evaluate	88
5.	Fase 5: Finalization and publication	92,5	C5: Evaluate	80

Implementing this online project-based worksheet aims to develop students' high-level thinking skills. The stages in the online project-based worksheets related to high-level thinking progress support this. In addition to developing student skills in compiling and carrying out tasks through projects that can produce new products or knowledge, project-based worksheets can also hone students' high-level thinking patterns.

Figure 1. Student activities while working on the worksheet

In implementing worksheets, phase 1 identifies the problem of student activity activities running smoothly. In phase 1, students are asked to determine the main idea, problem formulation, and hypothesis based on the problem formulation that has been made. The answers given by students from each group are different, so worksheet grids and rubrics are used to assess the results of worksheet work.

Phase 1 in project-based worksheets online has a cognitive level of C4 that can develop students' abilities in high-level thinking. Students determine the main idea based on the results of the analysis of the discourse on the use of sawdust as an adsorbent in the treatment of industrial liquid waste. In addition, students also analyse the appropriate problem formulation based on the discourse given to worksheets. The formulation of the problem must be an appropriate hypothesis. Students carry out this process by analyzing problems in worksheets. The process in phase I is in line with the research conducted by Santoso et al. (2020) that there are several processes carried out in project-based worksheets that become points in terms of analysis, such as criteria, arguments, and points of view that can be applied in determining the main idea, problem formulation or hypothesis.

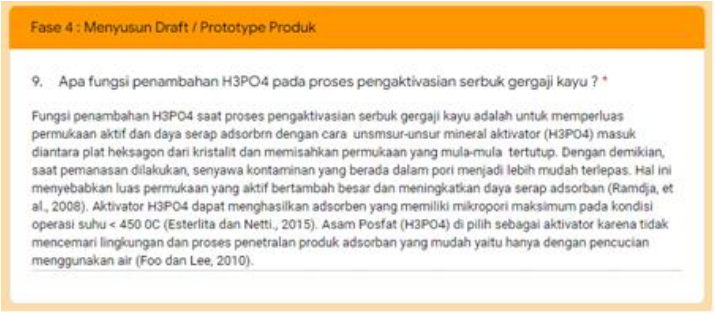
Figure 2. Student activities when preparing experimental designs

Implementing worksheets phase 2 is designing the product as a whole, which runs smoothly. In the questions in phase 2, students are asked to determine the purpose of the experiment, the principle of the experiment, the material tools to be used, and the design of the

experiment to be carried out. Project-based worksheets can guide students in making experiment designs, conducting experiments, and presenting experimental results (Apipah et al., 2019). In high-level thinking skills, the process carried out by students when determining experimental goals and principles is included in the C4 cognitive level, namely analyzing. Students can answer the principles and objectives of the experiment after analyzing the discourse on worksheets correctly so that, in this case, students are honed to be able to analyse it.

The process of applying worksheets in phase 3 is to conduct research according to the results of the researcher's observations; the activity is running well. In this phase, students begin to carry out research based on the experimental design that has been made and the materials that have been prepared. Students and their friends compile observation data from treatment tables, observations, and documentation. In this phase, each group must have compact teamwork with limited time, but all must be able to complete the task in time. The observation data filled in by each group was answered in detail and structured. Observations are filled out according to the stages of the procedure that are carried out, starting from making solutions, adsorption of waste samples, COD testing, TDS, and waste pH. Students also gain new skills and knowledge because, in this practicum, there are several discoveries regarding waste treatment in measuring parameters that follow environmental quality standards. They can also use tools such as TDS and pH meters to check waste parameters.

In phase 3, a high level of thinking ability in students can be developed, namely the C6 cognitive level. While working on it, students must be able to conduct experiments independently based on the design of experiments that have been made before. The process can be measured based on the way students compile or manage the findings obtained (Farida, 2017). The cognitive level that students can develop in phase 4 is the ability of C4 to analyze and the ability of C5 to evaluate. In this case, students in their work group must be able to analyze the results of the experiments carried out, whether they are appropriate or there are still those that are not suitable. The suitability of the answer is seen based on the relevant theory. The ability to think at a high level in students is different and adjusted again to the basic abilities of each student. The troubleshooting process becomes the most complicated part of identifying the problem. The level of complexity in the question is familiar to students; it is just that students are still confused about how to solve it. However, even so, the questions given are not what students imagine. If the questions are done according to the order of the commands on the questions and one can observe the questions well, then there will be a way out in solving the problem (Gani et al., 2018).


Fase 4 : Menyusun Draft / Prototype Produk

9. Apa fungsi penambahan H3PO4 pada proses pengaktivasian serbuk gergaji kayu ? *

Fungsi penambahan H3PO4 saat proses pengaktivasian serbuk gergaji kayu adalah untuk memperluas permukaan aktif dan daya serap adsorbrn dengan cara unsmsur-unsur mineral aktivator (H3PO4) masuk diantara plat heksagon dari kristalit dan memisahkan permukaan yang mula-mula tertutup. Dengan demikian, saat pemanasan dilakukan, senyawa kontaminan yang berada dalam pori menjadi lebih mudah terlepas. Hal ini menyebabkan luas permukaan yang aktif bertambah besar dan meningkatkan daya serap adsorban (Ramdja, et al., 2008). Aktivator H3PO4 dapat menghasilkan adsorben yang memiliki mikropori maksimum pada kondisi operasi suhu < 450 0C (Esterlita dan Netti., 2015). Asam Posfat (H3PO4) di pilih sebagai aktivator karena tidak mencemari lingkungan dan proses penetralan produk adsorban yang mudah yaitu hanya dengan pencucian menggunakan air (Foo dan Lee, 2010).

Figure 3. Worksheet results by students

The last phase in the project-based worksheets is phase 5, finalisation and publication. In this phase, students immediately presented the results of their experiments to other groups. In addition to presenting the experiment results, representatives of each group also showed the practicum results. They gave arguments and explanations related to the reduction-oxidation

titration practicum of the permanganometric method regarding the use of sawdust as an adsorbent in treating industrial liquid waste by measuring the waste parameters. In phase 5, students, namely C5, can develop a high level of thinking ability. Presenting this answer is related to evaluating activities because, in the process, we can see the extent of the practicum activities carried out by each group, whether they are appropriate or not appropriate, or whether they are the same between one group and another.

Using worksheets online using Google Forms is an exciting finding to study further. Working on questions online makes life cleaner and healthier because it does not use much paper as a writing medium in worksheets. Along with the development of technology and information, students can use technology more wisely. Using Google Forms, the process of implementing a worksheet can be carried out anytime and anywhere because its use is flexible. The use of Google Forms is one of the developments in science and technology that has advanced the world of education. The advantage of using Google Forms is that it can make students enthusiastic about doing worksheets, not monotonous, and improve their ability to respond (Sadewa et al., 2020).

In Google Forms, many features can be used as settings in working on worksheets. The worksheets applied in this study have a time limit for each question and stage in worksheets. This is made so that students can be disciplined and on time when working on worksheets so that worksheet work can be completed along with the learning process. In addition, the next feature on Google Forms can be used as a barrier for each stage so that the stages in worksheets can be carried out in order in the worksheets stage. The provisions for filling out the questions can be arranged, so all questions must be filled in. If the question has not been filled out, then it will not be able to proceed to the next stage. This will prevent students from forgetting or not filling out questions; like it or not, all questions must be filled in correctly. The Google form template is easy to understand and use, and there are not many other requirements, which is enough to have a Google account. Its easy use and lack of student access make it more straightforward to implement and apply to students (Mardiana & Purwanto, 2017). The ease of using Google Forms has also been proven through research conducted by Mulatsih (2020), which shows that using Google Forms is very easy, and the results of student answers can be seen through the spreadsheet data display or summary responses. In addition, students' answers can be neatly submitted in the email because the settings can be arranged according to needs.

Many benefits can be felt when using Google Forms as an alternative to implementing worksheets in online learning. However, the use of Google Forms also has disadvantages. The disadvantages that are felt when using project-based worksheets on the Google form page are the fear of data being lost because the period for submitting the task is long then, the limitations of the Google form in filling out the answer, for answers that must be tables, graphs, photos, and documents must be uploaded separately through google drive. This will cause the data filled in by students to be scattered. This is also proven by research conducted by Ngafifah (2020), which shows that the weakness of using worksheets lies in their limitations in that they cannot be used as an online discussion space, with limited design and incomplete export options.

Worksheets are carried out in groups so that a compact team is formed. The number of members of each practicum group is 4-5 people. The process is divided into the following: some fill out worksheets using laptops, some do practicums, and some write down the results of experiments and document each experiment. This busy activity will minimize the performance of students who are just silent. All students in their group have their duties. In this case, each student in his practicum group will get good performance scores, and all students will have the same skills in using tools and materials according to experimental procedures. After studying online for a long time, chemistry students must be skilled in carrying out practicum again. This is the same as the research conducted by Al-bari & Saputri (2020), which states that student performance when carrying out a chemical practicum has a percentage of 64.95%, which states

that practicum activities occur as a positive event.

Student performance when implementing project-based worksheets online is connected with the process of high-level thinking ability. In this case, the stages in project-based worksheets already connect with the cognitive level at a high level of thinking ability at the C4 level to analyse, C5 evaluate, and C6 create. The results of implementing project-based worksheets have also proven that students can become more skilled and creative and think critically when dealing with a problem. This is also proven by students' results in working on high-level thinking skills after completing worksheet work.

Questions No. 1 and No. 2 include the cognitive level of C4, namely analysing. Students analyse how the characteristics of adsorbents are suitable for use in absorbing harmful particulates in waste; this is a question because after carrying out the practicum, there are pretty significant changes in waste before and after adsorption. Students can analyse the factors that affect it and the characteristics of its adsorbents. In addition, students are also presented with graphs about waste treatment results by adopting them using sawdust adsorbents at different times. Through this question, students must be able to analyse to the masses whether adsorbents work well in stabilising waste parameters so that they can comply with environmental quality standards. Both of these questions are very helpful for students to develop their high-level thinking skills.

The average score of high-level thinking ability in question No. 1 and question No. 2 is 73 and 76, categorized as good, while the recapitulation of the value of high-level thinking ability at each cognitive level is specifically at C4, which is 74.5 with a good category. While working on this analysis question, some students still have not reached the maximum score. This is influenced by several factors, such as the lack of concentration of students in working on questions, incompatibility between the answers given by students with the grid on the questions, or the ability of students who have not been able to achieve the target. Students are suspected to lack the ability to link information to questions to be analysed, so their abilities are still weak (Harta et al., 2020).

The cognitive level of C4 should be a learning process that students can achieve well. However, there may still be students who have difficulty answering the question. This is because of the lack of training of students in analysing a problem in the problem. The questions that are usually given sometimes directly refer to the core of the language. In this case, students must be able to analyse the problems in the questions well to find solutions in solving the problem. The questions given to developing high-level thinking skills must include three categories, namely understanding the new learning context (transfer), the ability to reason questions, observe, connect and determine the complexity of the problem (critical thinking), and the ability to solve problems (Nurmawati et al., 2020).

The ability to think at a high level of C5, namely evaluating questions No. 3 and No. 4. In that question, students are tested through questions to evaluate the extent to which students understand the problem at that cognitive level. In this school, students are asked to check the COD content of known waste to determine whether it is worth discharging into the community environment or if it is still possible to damage the environment. This question is given to students because previously, in worksheets, the results of measuring waste parameters were obtained so that when given the same phenomenon, the same students would know how it should be. Students can re-examine the results of waste COD measurement on questions related to environmental quality standards that the government has set. Overall, students have been able to evaluate the questions given because previously, they have also been given the completion of C5 questions in worksheets, so that, in this case, students can develop their ability to think at a high level of C5, namely evaluating. In addition, the results of research conducted by Kusuma et al. (2017) are also proven in questions with the C5 level with a question model of correlating, concluding, comparing, and interpreting are categorised as very good.

The highest level of thinking ability is C6, or the ability to create. The cognitive level of C6 becomes the highest, so only one question is given that is relevant to the creation process. Students were asked to make an experimental design regarding making adsorbents from sawdust waste. In this case, some students understand the process of activating adsorbents, but some do not answer questions optimally. Students are asked to work on this question using various references such as relevant journals or books. Creating is challenging for students, especially when making experimental procedures. However, apart from all that, the average score of high-level thinking ability in question No. 5 is 80, with an outstanding category and a recapitulation of the value of high-level thinking ability for cognitive level C6, which is 80, with an outstanding category.

Based on Table 6 regarding project-based worksheets, resistance recapitulation with high-level thinking ability questions is categorised as very well; this is evidenced by the average score obtained in each worksheet phase and cognitive ability in high-level thinking ability questions. In line with the results of research conducted by Azizah and Widjajanti (2019), learning media can improve critical thinking skills and train students in implementing cognitive processes, namely with the help of project-based worksheets. This happens because students try to solve problems and find the right solution by not relying on one definite answer; a framework or product design is also needed in solving problems that will not be solved without cooperation and creative thinking.

CONCLUSION AND RECOMMENDATIONS

This study examined the understanding of first- and second-year students in the context of the global carbon cycle, an important aspect of environmental chemistry. The results of the GCCDI indicated that second-year students exhibited a superior comprehension of the global carbon cycle in comparison to first-year students. The application of qualitative analysis techniques in conjunction with surveys also demonstrated that second-year students exhibited a superior understanding of the global carbon cycle in comparison to first-year students. This understanding was classified into three categories. Although the understanding of second-year students is higher than that of first-year students, both groups are still classified as having a very low level of understanding.

The level of understanding of the carbon cycle remains relatively low, and misconceptions and misunderstandings are prevalent. Consequently, further research is required to provide a more comprehensive insight into students' understanding compared to scientists' perceptions. Although second-year students demonstrated some improvement in their understanding of the concept, there remained a notable deficiency in their comprehension of carbon flows between reservoirs. This analysis underscores the necessity of developing more engaging learning strategies, enhancing the identification of misconceptions, and conducting further research on the correlation between grade level and student comprehension. These endeavors are directed towards the enhancement of an adaptive and efficacious environmental chemistry curriculum to augment students' comprehension of the global carbon cycle.

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