Journal of Computers for Science and Mathematics Learning
ISSN 3047-4876 (online) & 3047-6755 (print)
August 2024, Vol. 1, No. 2, pp. 79–92

Scientia Publica Media

Research Article

Analysis of Students' Conceptual Understanding on Colloidal Materials Through the Flipped Classroom Learning Model Integrated Peer-Instruction

Tasya Fatacharmita[1], Tritiyatma Hadinugrahaningsih[2], Irwanto Irwanto[3]

[1]Department of Chemistry Education, Universitas Negeri Jakarta, Indonesia
[2]Department of Chemistry Education, Universitas Negeri Jakarta, Indonesia
[3]Department of Chemistry Education, Universitas Negeri Jakarta, Indonesia

Abstract
This study aims to obtain an overview of students' conceptual understanding on colloidal materials by applying the flipped classroom integrated with peer-instruction. The research method used is qualitative method. This research was conducted at SMA Negeri 8 Depok in the even semester of the 2021/2022 academic year. The research subjects were students of class XI IPA 3 which amounted to 39 students. Research data were collected from observation sheets, reflective journals, researcher notes, conceptual understanding sheets, conceptual understanding test, and interviews. In this study, to analyze the categories of students' conceptual understanding level used categories adapted from Abraham et al. (1992), namely understanding, lack of understanding, misconceptions, not understanding, and no response. Learning was conducted face-to-face used flipped classroom integrated peer-instruction. The flipped classroom integrated peer-instruction learning model consist of three stages, namely pre-class learning, in-class learning, and after-class learning. During in-class learning, students were given a ConcepTest. The percentage of ConcepTest results was 30% - 70% so that learning continued with group discussion. In all colloidal sub-materials, the majority of students were in the "understand" category with an average percentage of 60.17%. The conclusion of this study is that the flipped classroom learning model integrated with peer-instruction can help students develop students' conceptual understanding of colloidal material. The integrated flipped classroom and peer instruction can be an alternative in learning activities to develop students' conceptual understanding.

Keywords: Colloidal, Conceptual Understanding, Flipped Classroom, Peer-Instruction

Tasya Fatacharmita
tasyafatacharmita03@gmail.com

Received
July 12, 2024
Accepted
July 31, 2024
Published
August 10, 2024

Citation: Fatacharmita, T., Hadinugrahaningsih, T., & Irwanto, I. (2024). Analysis of students' conceptual understanding on colloidal materials through the flipped classroom learning model integrated peer-instruction. *Journal of Computers for Science and Mathematics Learning, 1*(2), 79–92.

1. INTRODUCTION

Education in the era of the Industrial Revolution 4.0 is required to produce high-quality graduates. Learning must go beyond mere knowledge or information transfer to enhance skills (Gleason, 2018). Student-centered pedagogy is needed. Additionally, teamwork helps acquire new knowledge and develop understanding. This aligns with the 2013 curriculum, which applies student-centered learning activities, as stipulated in the Minister of Education and Culture Regulation No. 36 of 2018. Students must be active during the learning process. Teachers only act as facilitators. Learning resources do not only come from teachers; students can independently search for various reading materials. Technological advancements also support interactive learning and help students understand lessons.

Conceptual understanding is defined as the ability of students to apply scientific concepts they have learned to real-world phenomena. It involves connecting several individual concepts to form a new concept (Nieswandt, 2007). In chemistry learning, conceptual understanding involves the ability to represent and interpret chemical problems using three forms of representation: macroscopic, sub-microscopic, and symbolic (Bowen & Bunce, 1997). Conceptual understanding is not only related to appropriate teaching strategies but also considers students' attitudes, motivation, or self-efficacy (Pintrich et al., 1993). Students with a better conceptual understanding of chemistry can also enhance their learning motivation (Cetin-Dindar & Geban, 2016).

Chemistry is one of the challenging subjects to study because it contains many abstract concepts that are difficult to understand. Students cannot directly observe the sub-microscopic level, making it hard to visualize reactions (Salame & Makki, 2021). Colloids are one of the chemistry topics that contain abstract and contextual concepts. Suits and Srisawasdi (2013) revealed that most students experience a gap between the abstract and difficult chemistry concepts learned at school (Srisawasdi & Panjaburee, 2019). Students struggle to solve problems because colloid concepts, especially those related to daily life, are not sufficiently explored in learning (Taher et al., 2018). Students lack an initial understanding of colloid concepts and terms (Miterianifa et al., 2020).

Based on interviews with chemistry teachers at SMA Negeri 8 Depok, in the 2020/2021 academic year, students' mastery of colloid topics decreased. Several classes had less than 50% mastery in colloid topics, whereas before the pandemic, students' mastery reached 70%. Students struggled to answer questions, and only a few were actively asking questions. One cause was the learning implementation itself. Students found it easier to understand when bringing examples of colloids from daily life and working in groups. Research also shows that students' conceptual understanding of colloid topics remains low. Mastery of concepts and learning outcomes in colloid topics are low, as evidenced by students' poor performance in answering questions at the analysis and evaluation levels and their weakness in problem-solving (Taher et al., 2018). Meaningful conceptual understanding for students results from a positive perception of success in chemistry class and is supported by a strong interest in various chemistry contexts (Nieswandt, 2007; Xu et al., 2013).

The learning model used by teachers is a crucial factor in achieving learning goals. The learning process using conventional models that rely on teacher-centered approaches has been deemed insufficient for enabling students to apply the concepts learned. Active learning models with interactions between students, students and technology, and students and teachers, using various information and technology sources, have become a research focus in the education field (Tosun & Taskesenligil, 2013). Students do not yet have a good conceptual understanding because they are not actively involved in learning. Conceptual understanding is essential in chemistry learning, such as in problem-solving. Therefore, a learning model is needed to enhance conceptual understanding.

The flipped classroom model is a new teaching strategy that aims to improve students' abilities and instill positive attitudes toward learning by using technology for outside-class learning and moving homework and in-class exercises into learning activities (Olakanmi, 2017). Peer-Instruction is an interactive teaching technique that actively involves students. Learning begins with the teacher posing conceptual questions and giving students a chance to answer. Students also engage in discussions with peers. Teachers provide feedback to students (Schell & Butler, 2018). Implementing the flipped classroom can increase students' comfort in problem-solving and confidence in the material. Students can also take more responsibility for their learning and become more aware of their learning abilities (Fautch, 2015). Brooks and Koretsky (2011) argue that peer instruction encourages students to engage actively in learning, think critically about the material, and learn from each other.

In student-centered learning, there are still challenges or it may not run as expected. Based on observations during teaching skills practice (PKM) at a high school in East Jakarta, students were not actively involved in ongoing chemistry learning. To help students understand the material, teachers sometimes provide educational videos. Additionally, Juniar et al. (2021) revealed that classroom learning tends to use lecture methods, making chemistry lessons not only difficult but also boring.

The flipped classroom and peer instruction models can make students active in learning because both models use a student-centered approach. Research findings reveal that the flipped classroom and peer instruction models, which use educational videos and peer discussions in their application, have a positive effect on learning. According to Macale et al. (2021), the integration of flipped classroom and peer instruction helps in solving and analyzing problems through peer discussions and aids in understanding lessons. Similarly, Fautch (2015) found that the flipped classroom is an effective pedagogical approach, with students showing positive attitudes and abilities toward the flipped classroom. Peer instruction leads to increased engagement, interaction, and conceptual understanding of students (Bergmann & Sams, 2012;

Schell & Butler, 2018). Additionally, according to Dumont, integrating flipped classroom and peer instruction can hone conceptual reasoning, abilities, and improve exam results (Ruiz, 2021).

Based on the aforementioned points, the researcher is interested in studying students' conceptual understanding using the flipped classroom integrated with the peer instruction model. The conceptual understanding of students being studied is on colloid topics.

2. METHOD

2.1 Research Method

This research uses a qualitative method. In qualitative research, researchers strive to understand or interpret phenomena and their meanings related to social or human issues (Creswell, 2013). Qualitative methods demonstrate the nature of the relationship between the researcher and the respondents. Research data were collected from observation sheets, researcher notes, students' conceptual understanding sheets, conceptual understanding tests, and interviews. The obtained data is descriptive data in the form of words or writings from the research subjects.

2.2 Research Subjects

The subjects of this research are 39 students of class XI Science 3 for the 2021/2022 academic year at SMA Negeri 8 Depok. The number of male students is 18, and the number of female students is 21. The age range of the students is approximately 15-17 years old. This research was conducted at SMA Negeri 8 Depok, located at Jalan H. M. Nasir No. 888, Cilodong Village, Cilodong District, Depok City, West Java. The research took place in the even semester of the 2021/2022 academic year.

2.3 Data Collection Instruments

Data collection in this research used several techniques, including:

2.3.1 Observation

Observation is conducted not only to observe the learning activities during the research but also to assess whether the ongoing learning has yielded the desired results, less or not as expected (Arikunto, 2013). In conducting this observation, two observers filled out observation sheets, and the researcher recorded the observations in researcher notes. The observation sheet contains aspects of conceptual understanding and the application of the flipped classroom integrated with peer-instruction learning model.

2.3.2 Reflective Journals

During the research, students must write reflective journals after each learning session. These reflective journals are daily records containing their feelings, involvement, and what they have gained during the learning process. Additionally, students can express their opinions on the suitability of the flipped classroom model integrated with peer-instruction with the colloid material, especially in understanding concepts.

2.3.3 Interviews

Interviews are conducted after the learning session. A total of 9 students are interviewed, consisting of 6 female students and 3 male students. The students are selected based on their performance levels, i.e., high, medium, and low. The researcher had prepared an interview guide containing questions about the application of the flipped classroom model integrated with peer-instruction and questions about colloid material. The interviews are semi-structured, meaning the questions posed to the students are not strictly bound to the interview guide. The purpose of the interviews is to determine the effectiveness of using the flipped classroom model integrated with peer-instruction in learning and to corroborate the students' answers on the conceptual understanding test sheets.

2.3.4 Test

Students' conceptual understanding is also measured or assessed through their answers on the conceptual understanding sheets provided at each meeting during the research, both individual results before grouping and after discussing with their group members, as well as from the final conceptual understanding test of the colloid material. The test sheet contains questions to measure conceptual understanding developed according to the indicators of competency achievement in colloid material and aspects of conceptual understanding. The results of the Content Index Validity (CVI) test show that the final conceptual understanding test questions are valid, as evidenced by a CVI value of 1, which meets the criterion that if the number of experts is 3, the value must be 1 to be considered valid.

2.4 Data Analysis

The collected data is then analyzed. According to Miles, Huberman, and Saldana (2014), qualitative data analysis techniques consist of three stages: data condensation, data display, and drawing and verifying conclusions.

2.4.1 Data Condensation

Data condensation refers to the process of selecting, focusing, simplifying, abstracting, and transforming the data collected during the research (Miles et al., 2014). By condensing the data, more directed data is produced. In this stage, data is summarized, coded, and refined to sharpen the analysis of students' conceptual understanding of colloid material through the use of the flipped classroom model integrated with peer-instruction, leading to final conclusions.

2.4.2 Data Display

A good data display is a strong form of qualitative analysis. Data is presented in a concise, organized manner, such as charts and tables, to be more easily understood and to proceed to the next analysis step, drawing conclusions (Miles et al., 2014). The data display should be systematic, well-decided on which data to include, and in what form to present it. In this research, students' conceptual understanding of colloid material and discussions on the application of the flipped classroom model integrated with peer-instruction are presented in narrative form, along with charts for categories of students' conceptual understanding.

2.4.3 Drawing and Verifying Conclusions

The third analysis stage is drawing and verifying conclusions. After the collected data undergoes analysis, it is interpreted by noting patterns, explanations, causal flows, and propositions (Miles et al., 2014). The data discussion becomes more explicit. After drawing conclusions, verification is necessary by rechecking the researcher's notes, observation sheets, interviews, and students' conceptual understanding test sheets on colloid material. The conclusions drawn are about students' conceptual understanding of colloid material through the flipped classroom model integrated with peer-instruction.

3. RESULTS AND DISCUSSION

Conceptual understanding sheets, conceptual understanding tests, interview results, reflective journals, and observation sheets were used to analyze students' conceptual understanding of colloid material. The level of students' conceptual understanding was measured using a conceptual understanding rubric adapted from Abraham et al. (1992). The categories of students' conceptual understanding levels are: understanding, less understanding, misconceptions, not understanding, and no response. The analysis results of students' conceptual understanding of colloid material are as follows:

3.1 Understanding of Colloids

In the first meeting, students were given conceptual understanding sheet 1A, which they completed individually before group discussions. In question 1a, data on dispersed phases, dispersing mediums, and the names of the types of substance mixtures were provided. From the given data, students had to determine whether the table represented types of colloids, solutions, or suspensions, and provide reasons for their answers. Students' understanding was categorized as "understanding," "less understanding," "misconceptions," and "not understanding." Many students still did not fully understand the definition of colloids. Here is an answer from student 33, categorized as "less understanding":

"*Colloids, because they can be distinguished by their forms between solid, liquid, and gas. Colloids are dispersions with a particle size larger than solutions but smaller than suspensions. They are in the middle.*"
(Student 33's Conceptual Understanding Sheet A, April 22, 2022)

The provided answer is more complete, and the language used is better after discussing with their friends. Other students also provided definitions that included the correct answer's keywords. Interview data showed similar results. Interviews were conducted with 9 students; 6 students were categorized as "understanding," 2 students as "less understanding," and 1 student as "not understanding." Student 11 explained that colloids are a dispersion system with particle sizes between 1-1000 nm. The particle size of colloids is larger than solutions and smaller than suspensions. Here is the interview transcript:

Researcher: "*Firstly, explain the definition of colloids in your own words!*"
Student 11: "*Colloids are a dispersion system with particle sizes larger than solutions and smaller than suspensions*."
Researcher: "*Do you know the particle size range for colloids?*"
Student 11: "*1-1000 nm*."
(Student 11 Interview, June 13, 2022)

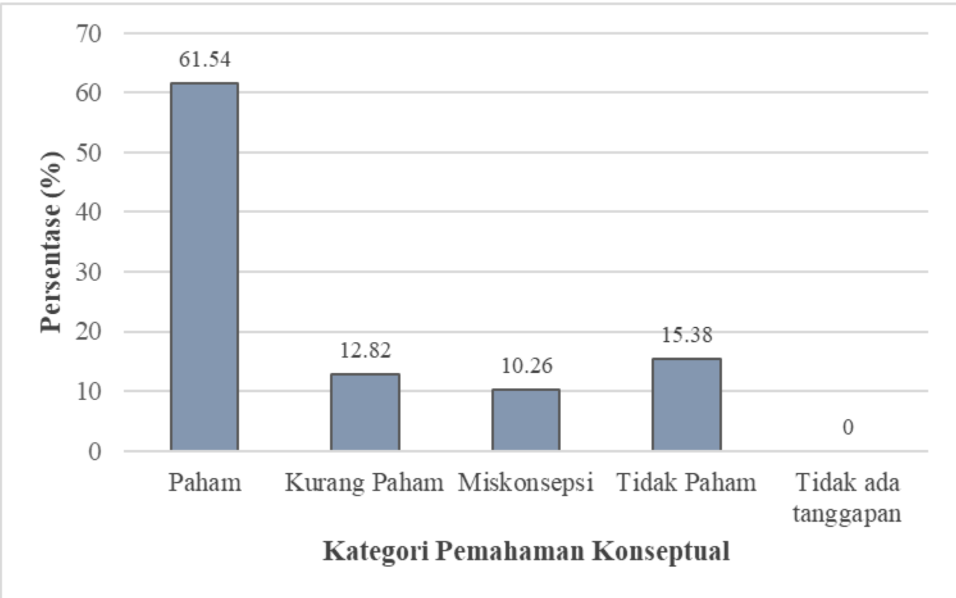


Figure 1. Percentage Chart of Conceptual Understanding Categories in the Sub-material Understanding of Colloids

The conceptual understanding test covering all colloid material learned was conducted in the third meeting. Students were asked to explain the definition of colloids. The test results showed various categories of students' understanding: "understanding," "less understanding," "misconceptions," "not understanding," and "no response." Students categorized as having "misconceptions" were confused about the basic concept of colloids. One of them, student 15, answered that colloids are mixtures with properties between homogeneous and heterogeneous mixtures. Other students with "misconceptions" answered with mixtures of solutions and suspensions or incorrect particle sizes. Misconceptions can occur because students have deeply rooted understanding that is hard to change. This aligns with Locaylocay et al. (2005), who stated that misconceptions are well-established within students and difficult to change even after guidance. Most students fell into the "understanding" category.

Students' conceptual understanding of defining colloids improved as they independently reviewed the material, discussed it with peers, and received additional brief explanations from the teacher. This aligns with Fautch (2015), who stated that flipped classrooms allow for deeper learning, critical thinking, and problem-solving during face-to-face class interactions with the teacher.

> "*Before the discussion, students already had a fairly good conceptual understanding, with only a few having low conceptual understanding. However, after the discussion, students' conceptual understanding increased, as seen from their worksheets before and after the discussion.*"
> (Observer 1 Observation Sheet, May 20, 2022)

To show the percentage comparison of each category of students' conceptual understanding, a bar chart was created. The percentage of students' conceptual understanding categories in the sub-material understanding of colloids is shown in Figure 1.

Based on the chart above, it can be seen that most students' conceptual understanding in the sub-material understanding of colloids falls into the "understanding" category. The percentage of students in the "understanding" category is 61.54%.

3.2 Differences between Solutions, Colloids, and Suspensions

Most students could differentiate between solutions, colloids, and suspensions. Before group discussions, students gave incomplete answers to question 1a on the conceptual understanding sheet. Some students answered with the correct concept but only provided one aspect of the differences among the three mixtures. Others gave answers from several aspects but were incorrect or confused between solutions, colloids, and suspensions. The researcher's notes showed that students were enthusiastic about discussing the differences when the teacher gave them the opportunity to share what they had learned before the lesson started.

> "*Many students mentioned the differences between solutions, colloids, and suspensions.*"
> (Researcher Notes, April 22, 2022)

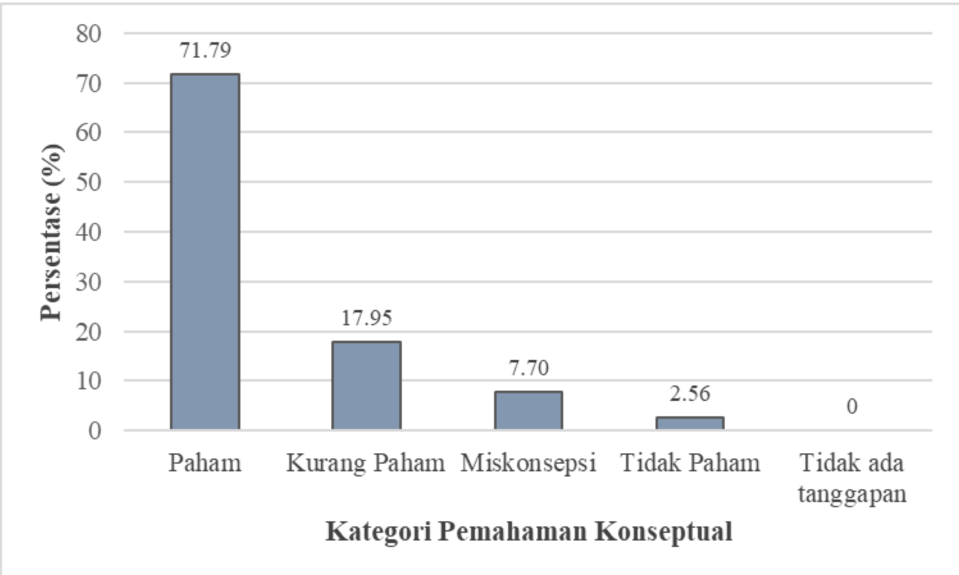


Figure 2. Percentage Chart of Conceptual Understanding Categories in the Sub-material Differences between Solutions, Colloids, and Suspensions

Students' understanding improved as seen from more complete and correct answers on the conceptual understanding sheet completed after the discussion. This aligns with Macale et al. (2021), who stated that students are given the opportunity to clarify answers through classroom discussions. Here is data from one student categorized as "understanding."

"*Solution: a homogeneous mixture of two or more substances. Particle size < 1 nm. Colloid: a heterogeneous mixture. Particle size is intermediate between solution and suspension. Suspension: a heterogeneous mixture. Particle size > 1000 nm.*"
(Student 33's Conceptual Understanding Sheet B, April 22, 2022)

"*After the discussion, students' conceptual understanding improved. Those who previously did not understand became more understanding. Students could correctly differentiate between solutions, suspensions, and colloids.*"
(Observer 2 Observation Sheet, April 22, 2022)

In question two of conceptual understanding test, 28 students were categorized as "understanding," 7 as "less understanding," 3 as "misconceptions," and 1 as "not understanding." Student 25 provided a correct concept and mentioned complete keywords for question two, thus falling into the "understanding" category.

The percentage comparison of conceptual understanding levels for the sub-material differences between solutions, colloids, and suspensions is presented in a bar chart shown in Figure 2. Based on Figure 2, the level of students' conceptual understanding in the sub-material differences between solutions, colloids, and suspensions falls into the "understanding" category with a percentage of 71.79%.

3.3 Dispersed Phase and Dispersion Medium

The sub-material dispersed phase and dispersion medium were studied from the first meeting. Before the discussion in the first meeting, many students still did not understand this sub-material. Many chose the wrong answers, and some did not provide reasons for their choices. After the discussion, the number of students categorized as "understanding" increased to 24, followed by 5 students as "less understanding." However, 6 students still did not understand, and 2 others gave no response.

This aligns with Nerantzi (2020), who stated that peer support and guidance can focus on problem-solving or challenges, with students actively involved in activities. Students "understood" that in dispersion systems, there are dispersed phases and dispersion mediums. On the conceptual understanding sheet in the first meeting, students could determine solid as the dispersed phase, as seen in the answer from student 4 below:

"*(1) Dispersed phase, because the substance is evenly spread in another substance.*"

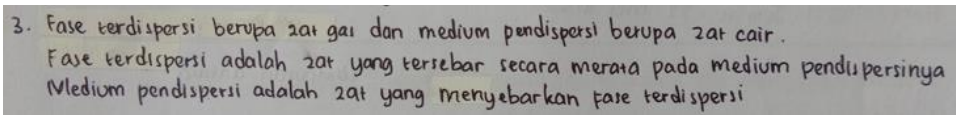
(Student 4's Conceptual Understanding Sheet A, April 22, 2022)

During the discussion, students admitted they sometimes confused identifying the dispersed phase and dispersion medium in colloid examples, requiring time to analyze their answers. Students were still confused as they had not fully understood the concepts of dispersed phase and dispersion medium. This is reflected in the data below:

"*Some students sometimes confuse identifying the dispersed phase and dispersion medium, so they need to focus when answering. For example, students 2, 18, 27, and 33.*"

(Researcher Notes, April 22, 2022)

Students understand that the dispersion system in the foam, which is gas in liquid. The gas substance is the dispersed phase, which is the substance that is evenly dispersed in the dispersing medium, while the liquid substance is the dispersing medium, which is the substance that disperses the dispersed phase, according to the answer in Figure 3 as follows:


3. Fase terdispersi berupa zat gas dan medium pendispersi berupa zat cair.
Fase terdispersi adalah zat yang tersebar secara merata pada medium pendispersinya
Medium pendispersi adalah zat yang menyebarkan fase terdispersi

("3. The dispersed phase is a gaseous substance and the dispersing medium is a liquid. The dispersed phase is a substance that is evenly dispersed in the dispersing medium. The dispersing medium is a substance that disperses the dispersed phase.")

Figure 3. Conceptual Understanding Test Answer Number 3 of Student 20

The bar chart in Figure 4 below shows the percentage comparison of students' conceptual understanding categories for the sub-material dispersed phase and dispersion medium.

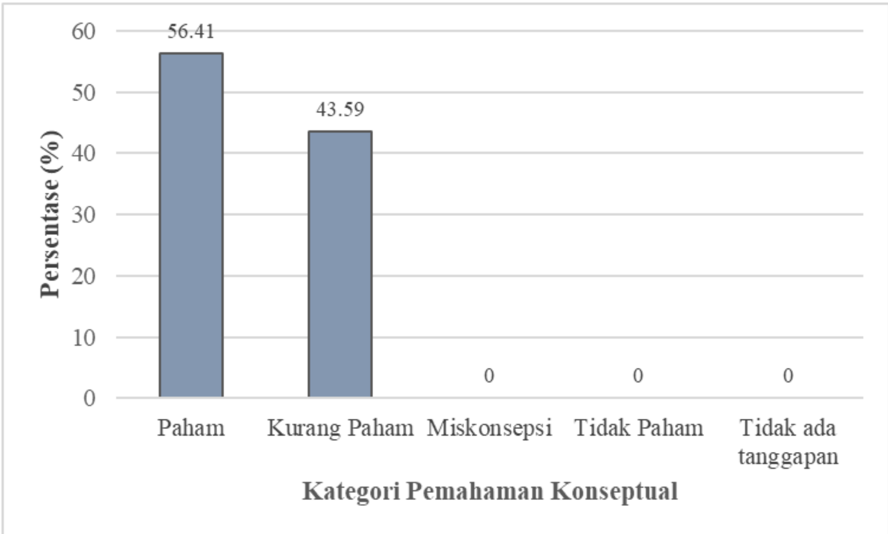


Figure 4. Percentage Chart of Conceptual Understanding Categories in the Sub-material Dispersed Phase and Dispersion Medium

Based on the data in Figure 4, it can be seen that the highest category of students' conceptual understanding is "understanding" with a percentage of 56.41%.

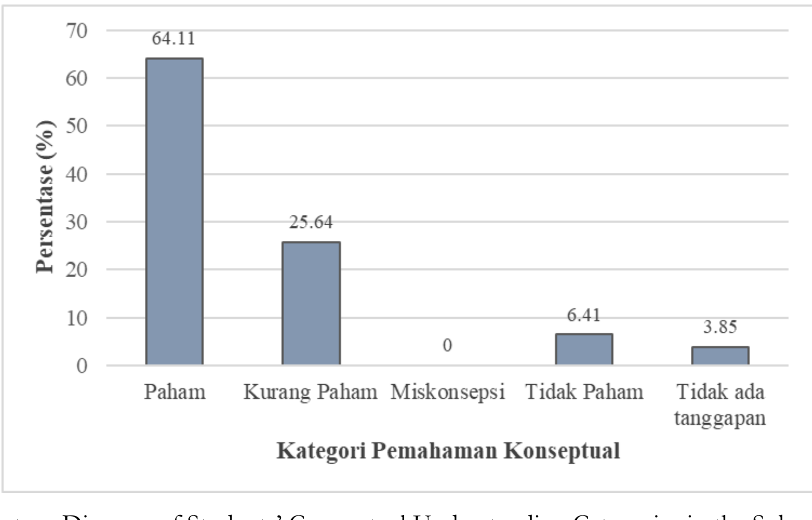


Figure 5. Percentage Diagram of Students' Conceptual Understanding Categories in the Sub-material Types of Colloids

3.4 Types of Colloids

In the first meeting, students could provide examples of types of colloids or identify the types of colloids from examples given in the conceptual understanding sheet. Before the discussion, most students were categorized as "understanding." There were two questions for this sub-material. In question 3, the statement provided rice and butter as examples of gel or solid emulsion. Students were asked to determine whether the statement was true or false. Students' conceptual understanding varied, categorized as "understanding," "less understanding," "misconceptions," "not understanding," and "no response."

> "*True. Because both are created from a liquid dispersed phase and a solid dispersion medium.*"
> (Student 10's Conceptual Understanding Sheet 1A, April 22, 2022)

Based on the data in Figure 5, students' conceptual understanding of the sub-topic "types of colloids" falls into the "understanding" category. The percentage of the "understanding" category is 64.11%. Fautch (2015) argued that with the flipped method, students can take more responsibility for their learning activity and be more aware of what they are capable of learning.

3.5 Properties of Colloids

The sub-topic "properties of colloids" was covered in the second meeting. Generally, students already understood the properties of colloids but still struggled to answer questions about some colloid properties when applied in problems. On the conceptual understanding sheet, only about 9 students answered question number 1 correctly and completely. The rest of the students were categorized as "less understanding," "misconceptions," "not understanding," and "no response." From the students' answers, it is evident that they still struggled to correctly identify the properties of colloids in the application process of washing clothes. This is evidenced by one student's answer categorized as "misconceptions" below:

> "*(1) Dialysis. The process of washing colloids with water. The colloid is placed in a semipermeable bag, and the impurity ions migrate so that the colloid is free from impurity ions.*"
> (Student 7's Conceptual Understanding Sheet A, May 20, 2022)

Student 11 explained the coagulation of negatively charged As_2S_3 colloids, stating it is most effective when a highly positive solution, such as $AlCl_3$, is added. Additionally, other students understood that to coagulate negatively charged colloids, it is effective to add a positively charged electrolyte solution, with the most effective being the one with the highest charge. In the problem, the solution with the highest positive charge is $AlCl_3$, which has Al ions with a 3+ charge.

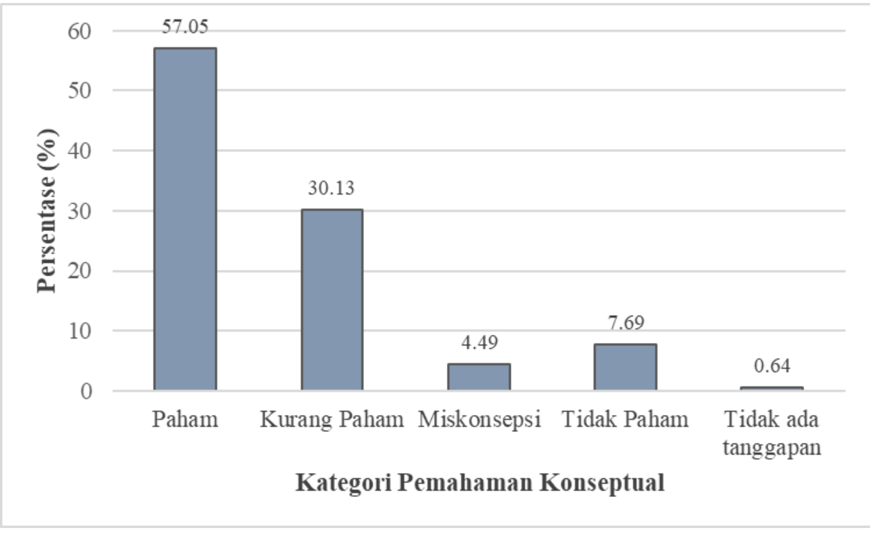


Figure 6. Percentage Diagram of Students' Conceptual Understanding Categories in the Sub-topic "Properties of Colloids"

Based on the data in Figure 6, it can be concluded that students' conceptual understanding of the sub-topic "properties of colloids" is in the "understanding" category, with a percentage of 57.05%.

3.6 Methods of Making Colloids

The sub-topic "methods of making colloids" was studied in the second meeting. On question number 4 of the conceptual understanding sheet, students could provide appropriate explanations. Students stated that the condensation method is indeed one of the methods for making colloids. Most answers were complete and correct. After group discussions, students' understanding improved further. Student 20 was categorized as "understanding" because their explanation was aligned with the correct concept. Here is the answer provided by the student:

> "*Because there are 2 methods of making colloids, one of which is condensation. The condensation method involves creating a colloid system by combining atoms, molecules, or smaller particles to form larger particles that match the size of colloid particles*."
> (Student 20's Conceptual Understanding Sheet B, May 20, 2022)

Student 10 was categorized as "not understanding" because their explanation did not align with the correct concept. This could occur because Student 10 and some others did not watch the learning video before class and were not focused during the discussion. Schultz et al. (2014) suggested that students might show negative results if the video is too long, missing class interaction, and facing technological barriers. This is reflected in the researcher's notes below:

> "*Some students did not respond in the 'Reflection Room'*."
> (Researcher's Notes, May 20, 2022)

> The explanation given by Student 10 did not align with the context or the material being studied. Here is Student 10's answer:
> "*Condensation is the change of a substance's state to a more solid form*."
> (Student 10's Conceptual Understanding Sheet B, May 20, 2022)

Based on the data in the percentage diagram of conceptual understanding categories shown in Figure 7, students' conceptual understanding of the sub-topic "methods of making colloids" is mostly at the "understanding" level, with the percentage for the "understanding" category being 53.85%. Schell and Mazur (2015) argued that grouping strategies, peer discussions, and idea exchange increase the likelihood of better learning outcomes, especially in conceptual understanding.

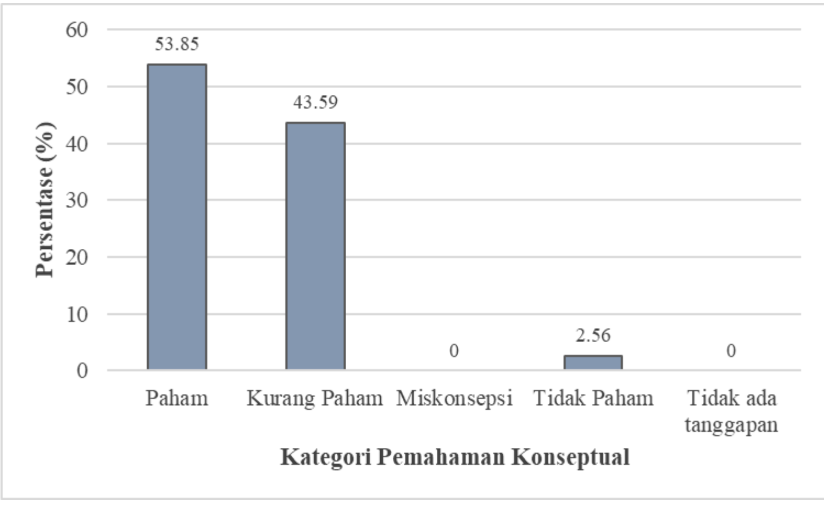


Figure 7. Percentage Diagram of Students' Conceptual Understanding Categories in the Sub-topic "Methods of Making Colloids"

3.7 Use of Colloids in Daily Life

In the second meeting's conceptual understanding sheet, question number 5 presented one of the uses of colloids in daily life, such as paint used to coat the surface of a material. Students were asked to determine whether the given statement was true or false, along with an explanation related to the colloid system. The results showed that the "less understanding" category exceeded the "understanding" category by only 2 students. The rest were categorized as "not understanding" and "no response." Here is an answer from a student categorized as "less understanding":

"*True. Because paint is a liquid dispersion medium called sol.*"
(Student 21's Conceptual Understanding Sheet A, May 20, 2022)

Most students "understanding" that in dialysis, dirty blood is drained and filtered through a semipermeable membrane. Once the blood is free of dirty ions or molecules, clean blood is passed back into the body.

To compare each category of students' conceptual understanding in the sub-topic "use of colloids in daily life," a diagram is presented in Figure 8.

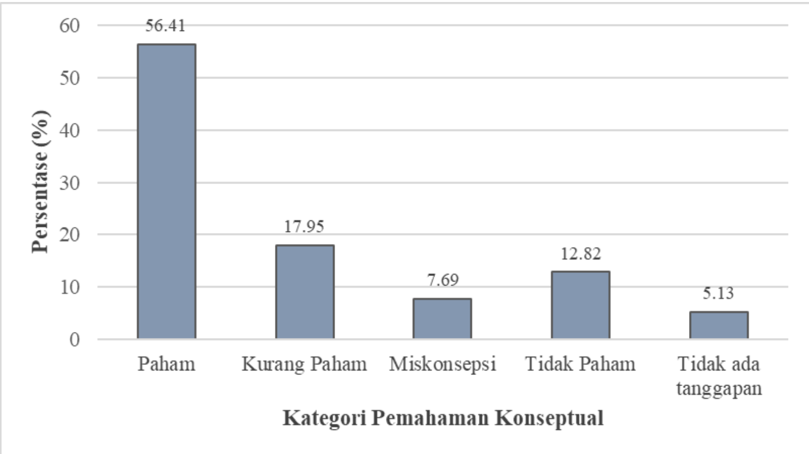


Figure 8. Percentage Diagram of Students' Conceptual Understanding Categories in the Sub-topic "Use of Colloids in Daily Life"

Based on the data in Figure 8, most students were categorized as "understanding." The percentage of students' conceptual understanding in the "understanding" category is 56.41%.

From the data analysis results, it can be concluded that in each sub-topic of colloids, the majority of students fall into the "understanding" category, with percentages for each sub-topic being 61.54%, 71.79%, 56.41%, 64.11%, 57.05%, 53.85%, and 56.41%. This indicates that students have a good understanding of colloid material, and the flipped classroom model integrated with peer instruction can facilitate students' learning and develop their conceptual understanding of colloid material. Macale et al. (2021) revealed that flipped classrooms and peer instruction encourage students to exhibit cooperative and supportive behavior during discussions and class activities, share ideas in class, respect others' opinions, use technology, and improve learning outcomes.

Students who watched the learning video mostly understood the colloid material, with only a few sub-topics remaining partially unanswered, such as Student 20 not fully understanding the methods of making colloids, Students 25 and 27 not fully understanding coagulation properties, and Student 17 not fully understanding the dispersed phase, dispersion medium, and properties of colloids. Student 2 did not fully understand the differences between solutions, colloids, and suspensions and the properties of colloids. Students 4 and 27 also understood colloid material but lacked understanding of colloid properties. Some students were not categorized as "understanding" possibly due to inadequate feedback during class, difficulties in studying chemistry, insufficiently helpful videos, not watching the learning video, or not following each learning step properly.

4. CONCLUSION AND RECOMMENDATIONS

Based on the research results, the majority of students' conceptual understanding in each sub-topic of colloids falls into the "understanding" category, with an average percentage of 60.17%. The highest level of conceptual understanding was observed in the sub-topic "differences between solutions, colloids, and suspensions," with a percentage of 71.79% for the "understanding" category. The sub-topic "methods of making colloids" had the lowest percentage in the "understanding" category at 53.85%. Most of the answers provided contained the correct concepts. Students also corrected and completed their answers correctly when filling out the conceptual understanding sheets again. This indicates that the integrated flipped classroom and peer instruction model applied can develop students' conceptual understanding of colloid material.

The integrated flipped classroom and peer instruction model can help students have a better understanding of the material because they have the opportunity to delve into the material through peer discussions. Before classroom learning, students have already studied the material independently at home, either by watching educational videos or reading the material to be learned. Additionally, students can attempt to redo the conceptual understanding sheets after discussions. Therefore, if students are still unsure or have less understanding when working on the conceptual understanding sheets before discussions, they can exchange ideas or work together with their peers to find the correct answers. This makes learning more interesting and encourages students to be more active, courageous in expressing opinions, and asking questions if there is something they do not understand.

The integrated flipped classroom and peer instruction model can be an alternative in learning activities to develop students' conceptual understanding. However, the rather lengthy learning stages require a considerable amount of learning time to be more effective. Conducting face-to-face learning activities (KBM) also supports effective results. Moreover, teachers must ensure that all students watch the videos or study materials and follow the given instructions well to cover the existing weaknesses. The material suitable for this learning model is one that contains more concepts.

Data Availability Statement. All data can be obtained from the corresponding author.

Conflicts of Interest. The authors declare no conflicts of interest.

Funding. This research received no external funding.

REFERENCES

Abraham, M. R., Grzybowski, E. B., Renner, J. W., & Marek, E. A. (1992). Understandings and misunderstandings of eighth graders of five chemistry concepts found in textbooks. *Journal of Research in Science Teaching*, *29*(2), 105–120. https://doi.org/10.1002/tea.3660290203

Arikunto, S. (2013). *Prosedur penelitian: suatu pendekatan praktik*. Rineka Cipta.

Bergmann, J., & Sams, A. (2012). Flip your classroom: reach every student in every class every day (pp. 120-190). International Society for Technology in Education.

Bowen, C. W., & Bunce, D. M. (1997). Testing for Conceptual Understanding in General Chemistry. *The Chemical Educator*, *2*(2), 1–17.

Brooks, B. J., & Koretsky, M. D. (2011). The influence of group discussion on students' responses and confidence during peer instruction. *Journal of Chemical Education*, *88*(11), 1477–1484. https://doi.org/10.1021/ed101066x

Cetin-Dindar, A., & Geban, O. (2016). Conceptual understanding of acids and bases concepts and motivation to learn chemistry. *Journal of Educational Research*, *110*(1), 85–97.

Creswell, J. W. (2013). *Qualitative inquiry & research design: Choosing among five approaches* (3rd Ed.). SAGE Publications.

Fautch, J. M. (2015). The flipped classroom for teaching organic chemistry in small classes : Is it effective ? *Chemistry Education Research and Practice*, *16*, 179–186. https://doi.org/10.1039/C4RP00230J

Gleason, N. W. (2018). Introduction. In *Higher education in the era of the fourth industrial revolution* (pp. 6–7). Palgrave Macmillan.

Juniar, A., Fardilah, R. D., & Tambunan, P. M. (2021). The distinction of students' science process skill and learning activities between guided inquiry and conventional learning with experiment. *Journal of Physics: Conference Series*, *1788*(012043), 1–11.

Locaylocay, J., Van Den Berg, E., & Magno, M. (2005). Changes in college students' conceptions of chemical equilibrium. *Research and the Quality of Science Education*, 459–470.

Macale, A., Lacsamana, M., Quimbo, M. A., & Centeno, E. (2021). Enhancing the Performance of Students in Chemistry Through Flipped Classroom with Peer Instruction Teaching Strategy. *LUMAT*, *9*(1), 717–747. https://doi.org/10.31129/LUMAT.9.1.1598

Melati, M., & Hadinugrahaningsih, T. (2024). The effect of numbered head together (nht) in a flipped classroom environment on students' self-efficacy and achievement on colloid topics. *Journal of Research in Education and Pedagogy, 1*(1), 24-29.

Miles, M. B., Huberman, A. M., & Saldana, J. (2014). *Qualitative Data Analysis: A Methods Sourcebook* (3rd Ed). SAGE Publications.

Miterianifa, Ashadi, Saputro, S., & Suciati. (2020). Analysis of errors and scaffolding in problem-solving processes on colloid topic for class XI senior high school. *AIP Conference Proceedings*, *2296*(1), 1–8. https://doi.org/10.1063/5.0030457

Nerantzi, C. (2020). The Use of Peer Instruction and Flipped Learning to Support Flexible Blended Learning During and After the COVID-19 Pandemic. *International Journal of Management and Applied Research*, *7*(2), 184–195. https://doi.org/10.18646/2056.72.20-013

Nieswandt, M. (2007). Student affect and conceptual understanding in learning chemistry. *Journal of Research in Science Teaching*, *44*(7), 908–937.

Olakanmi, E. E. (2017). The Effects of a Flipped Classroom Model of Instruction on Students' Performance and Attitudes Towards Chemistry. *Journal of Science Education and Technology*, *26*(1), 127–137. https://doi.org/10.1007/s10956-016-9657-x

Pintrich, P. R., Marx, R. W., & Boyle, R. A. (1993). Beyond cold conceptual change: The role of motivational beliefs and classroom contextual factors in the process of conceptual change. *Review of Educational Research*, *63*(2), 167–199.

Rakhmalinda, F. (2024). Trends in flipped classroom of higher education: bibliometric analysis (2012–2022). *Journal of Research in Mathematics, Science, and Technology Education, 1*(1), 19–34.

Ruiz, C. G. (2021). The effect of integrating kahoot! and peer instruction in the spanish flipped classroom : the student perspective. *Journal of Spanish Language Teaching*, *8*(1), 1–16. https://doi.org/10.1080/23247797.2021.1913832

Salame, I. I., & Makki, J. (2021). Examining the use of PhET simulations on students' attitudes and learning in general chemistry II. *Interdisciplinary Journal of Environmental and Science Education*, *17*(4), 1–9. https://doi.org/10.21601/ijese/10966

Schell, J. A., & Butler, A. C. (2018). Insights From the Science of Learning Can Inform Evidence-Based Implementation of Peer Instruction. *Frontiers in Education*, *3*(33), 1–13. https://doi.org/10.3389/feduc.2018.00033

Schell, J., & Mazur, E. (2015). Flipping the Chemistry Classroom with Peer Instruction. In J. Gracia-Martinez & E. Serrano-Torregrosa (Eds.), *Chemistry Education: Best Practices, Opportunities and Trends* (pp. 319–343). Wiley-VCH. https://doi.org/10.1002/9783527679300.ch13

Schultz, D., Duffield, S., Rasmussen, S. C., & Wageman, J. (2014). Effects of the Flipped Classroom Model on Student Performance for Advanced Placement High School Chemistry Students. *Journal of Chemical Education*, *91*(9), 1334–1339. https://doi.org/10.1021/ed400868x

Srisawasdi, N., & Panjaburee, P. (2019). Implementation of game-transformed inquiry-based learning to promote the understanding of and motivation to learn chemistry. *Journal of Science Education and Technology*, *28*(2), 152–164. https://doi.org/10.1007/s10956-018-9754-0

Taher, T., Erdawati, & Afrizal. (2018). Pengaruh Model Problem Based Learning dan Tipe Kepribadian Terhadap Kemampuan Berpikir Kritis Siswa pada Materi Koloid. *Jurnal Riset Pendidikan Kimia*, *8*(1), 28–34. https://doi.org/10.21009/JRPK.081.03

Tosun, C., & Taskesenligil, Y. (2013). The effect of problem-based learning on undergraduate students' learning about solutions and their physical properties and scientific processing skills. *Chemistry Education Research and Practice*, *14*(1), 36–50.

Xu, X., Villafane, S. M., & Lewis, J. E. (2013). College students' attitudes toward chemistry, conceptual knowledge and achievement: Structural equation model analysis. *Chemistry Education Research and Practice*, *14*(2), 188–200. https://doi.org/10.1039/c3rp20170h

Yulita, M. G. P. (2024). Research trends on flipped classroom: a bibliometric analysis (2012–2023). *Journal of Computers for Science and Mathematics Learning, 1*(1), 1-13.