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A Study of Students' Difficulties and Conceptual Understanding of the Qualitative and Quantitative Analysis of Organic Compound Elements

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ABSTRAK

Penelitian ini menyelidiki kesulitan belajar dan pemahaman konsep yang dihadapi oleh 28 siswa kimia dalam perkuliahan analisis kualitatif dan kuantitatif unsur senyawa organik yang menerapkan model pembelajaran RADEC (Read, Answer, Discuss, Explain, and Create). Hasil penelitian menunjukkan adanya peningkatan dengan kategori sedang pada pemahaman konsep, dengan skor N-Gain sebesar 0,34. Namun ada beberapa faktor yang menyebabkan rendahnya pemahaman, seperti 28% siswa melaporkan kesulitan dengan materi Kjeldahl, 24% dengan topik Dumas, 5% dengan topik penghancuran Lassaigne, 9% dengan topik Kjeldahl dan Dumas, dan 5% dengan topik topik destruksi, distilasi, dan titrasi. Selain itu, 24% mahasiswa tidak memahami makna pertanyaan, penyampaian materi perkuliahan, dan penulisan persamaan reaksi. Kurangnya persiapan seperti membaca sebelum perkuliahan juga berkontribusi pada pemahaman yang rendah.

ABSTRACT

The study examines the learning difficulties and understanding of concepts faced by 28 chemistry students in organic compound element analysis courses using the RADEC learning model. The results showed a moderate increase in understanding. Still, several factors contributed to the low understanding, such as 28% of students reporting difficulty with Kjeldahl material, 24% with Dumas topics, 5% with Lassaigne destruction topics, 9% with Kjeldahl and Dumas topics, and 5% with digestion, distillation, and titration. Additionally, 24% of students did not understand the meaning of the questions, the lecture material's delivery, and the writing of reaction equations. Lack of preparation, such as reading before lectures, also contributed to low understanding.

1. INTRODUCTION

In recent studies, organic chemistry is identified as a challenging field due to its abstract and complex concepts (Rosly et al., 2021). Students often struggle with grasping the extensive content, particularly when relying on rote memorization instead of developing a deeper conceptual understanding. Studies emphasize active learning strategies, have shown to improve students' comprehension by connecting new concepts to prior knowledge, promoting meaningful engagement in organic chemistry courses (Gupte et al., 2021; Salame et al., 2019). The most challenging topics in organic chemistry at the undergraduate level are functional groups, stereochemistry, organic reactions, mechanisms (Salame et al., 2019, 2020), determination of reaction types, construction of reaction mechanisms, and characterisation of organic reactions (Rosly et al., 2021).

Organic chemistry has excellent economic significance because its topics are intertwined with other courses, such as physical chemistry, biochemistry, and applied sciences. So, a bad foundation for organic chemistry will have a long-term adverse effect and cause confusion and difficulties for beginner students (Lopez et al., 2011; O'Dwyer & Childs, 2017). Factors such as misconceptions, lack of practical ac

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tivities, and difficulty in understanding complex concepts like isomerism and reaction mechanisms are the root of the problem (Sibomana et al., 2021).

The conceptual understanding of science is a complex phenomenon, a combination of understanding a single concept, such as oxidation, or more complicated concepts, such as a redox reaction (declarative or factual knowledge) (Nieswandt, 2007). It is indisputable that knowledge of breadth and depth are interrelated and essential aspects of conceptual understanding (Zhu et al., 2023) and chemical experimental skills (Alao & Guthrie, 1999; Reid & Shah, 2007). In this study, conceptual understanding is defined as knowledge of basic concepts and the ability to use principles in the qualitative and quantitative analysis of organic compound elements.

On the one hand, many researchers have identified students' perceptions that chemistry is a challenging material so that students experience difficulties in learning organic chemistry (Mackey et al., 2022). Many intrinsic and extrinsic factors contribute to students' perceptions of difficulties with organic chemistry (O'Dwyer & Childs, 2017). The participants' views are largely dominated by external factors, many of which are beyond the control of teachers and learners. The critical role of teachers' empathy and other intrinsic factors are identified and addressed to facilitate meaningful learning. Innovative teaching strategies and correcting misconceptions are the solution. They will improve students' conceptual understanding and academic achievement in organic chemistry.

Many innovative learning models claim to enhance students' understanding of concepts, including the RADEC learning model. The learning model RADEC was first developed by (Sopandi, 2017); it is a learning model that stimulates students to learn actively, not only to master the learning concepts learned but also to master skills and attitudes comprehensively so that it can facilitate students to develop an understanding of concepts, attitudes, and behaviour based on sustainable awareness. The RADEC model was designed considering the unique conditions existing in Indonesia, both concerning the curriculum and the characteristics of teachers and students (Lestari et al., 2022; Sopandi, 2017).

Read, Answer, Discuss, Explain, and Create is an extension of RADEC. The learning model of RADEC is based on the Indonesian educational system that requires students to understand many concepts of science in a limited time, and the syntax of the learning model is easy to apply, so it is worthy of being used as an alternative to innovative learning models in Indonesia (Pratama et al., 2019). RADEC is a learning model that can encourage students to develop 21st-century skills and master the learning concepts learned (Lestari et al., 2020) so that students can gain practical experience in the learning process (Siregar et al., 2020).

Thus, this study focuses on identifying various difficulties in studying the material of Organic Compound Analysis and improving students' understanding of the concepts when applying the learning model RADEC. This research is expected to contribute to the sustainability of science learning, especially in chemistry studies, by emphasizing the use of alternative effective learning models to reduce the learning difficulties of organic chemistries experienced by students so that it can ultimately improve student understanding of the concept of the material.

2. METHOD

The research used pre-experimental methods with one-group design pretest-posttest, where researchers studied only one group and applied interventions during the experiment (Creswell & Clark, 2018). This method obtains data on students' understanding of chemistry concepts before and after intervention. The intervention in this study is applying the learning model RADEC with three meetings (each meeting of 2 credits) on the material Qualitative and Quantitative Analysis of Organic Compound Elements (Table 1).

Table 1. Pre-Experimental Research Design

Sample	Pretest	Intervention	Posttest
One group of class	Conceptual understanding test about Qualitative & Quantitative Analysis of Organic Compound Elements; "Length of Reading Time" questionnaire	Read, Answer, Discuss, Explain, and Create (RADEC) learning model	Conceptual understanding test about Qualitative & Quantitative Analysis of Organic Compound Elements; "students' perception about learning difficulty" questionnaire

The RADEC learning model is a learning strategy that includes reading, answering, discussing, explaining, and creating stages, as developed by Sopandi (2017). In this study, in the "read" phase, students are guided independently to dig for information from various learning sources such as books, modules, and teaching materials, as well as other sources of information related to a problem or issue or questions given. In the "answer" phase, the students will answer pre-learning questions (pretest) based on information obtained from the reading phase. In the " discuss" phase, students can develop and discuss a problem-solving plan or questions given. In the "explain" phase, the students can explain the answers to a given question or question, and in the "create" stage, learners can apply answers to a given issue or question in the form of daily tasks. The stages of each RADEC model syntax can be seen in Figure 1.

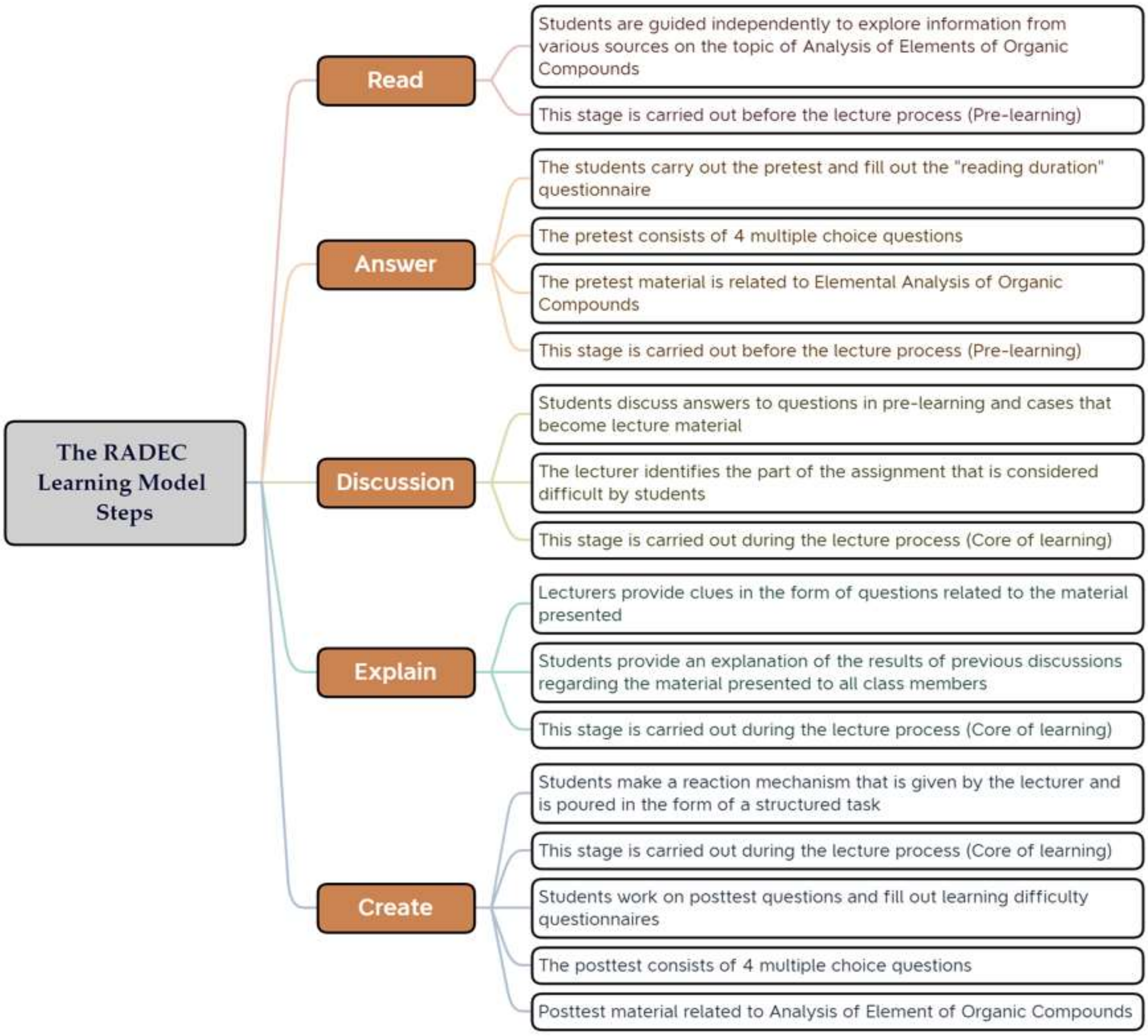


Figure 1. The stages of read, answer, discuss, explain, and create (RADEC) learning model

Participants in the study were as many as 28 students of the chemistry study program at the Faculty of Mathematics and Natural Sciences at one of the colleges in Bandung. The purposive sampling method is used when determining the research respondents, i.e., by randomly selecting them for the research objectives. The respondent involved in the study was a second-semester student taking a Monofunctional Organic Chemistry course on Qualitative and Quantitative Analysis of Organic Compound Elements. The students involved were 21% male and 79% female.

The instruments used in data collection are the test instrument (multiple-choice questions) and the non-test instrument (questionnaire). The test tool consists of a pretest and a posttest question comprised of four multiple-choice questions distributed through the Quizziz application (Table 2). The non-tests are questions related to the duration of reading and the student's perception of difficulty understanding the material presented (Table 3).

Table 2. Pretest and Posttest Questions

No.	Questions	
	Pretest	**Posttest**
1	*Wöhler berhasil membuat urea bukan dari makhluk hidup namun dari ammonium sianat, dengan adanya penemuan sangat menentang teori dari?* Wöhler succeeded in making urea not from living creatures but from ammonium cyanide, with the presence of a discovery that strongly contradicted the theory of?	*Beberapa prinsip reaksi yang banyak digunakan untuk penentuan unsur senyawa organic menggunakan Analisa kualitatif adalah?* What are some of the reaction principles that are widely used for determining elements of organic compounds using qualitative analysis?
2	*Yang termasuk perbedaan sifat senyawa organik dan anorganik adalah kecuali?* Which includes the difference in the properties of organic and inorganic compounds, except?	*Salah satu cara pengujian kualitatif yang dapat menentukan hampir semua unsur pada senyawa organik adalah menggunakan?* One way of qualitative testing that can determine almost every element on an organic compound is to use it?
3	*Yang termasuk metode analisis kuantitatif unsur N adalah?* Which included the method of quantitative analysis of element N?	*Salah satu penemuan Lavoisier yang menyumbangkan perkembangan penemuan kimia organik adalah?* One of Lavoisier's discoveries that contributed to the development of organic chemistry was?
4	*Pada percobaan untuk menganalisis kuantitatif unsur C dan H pada sampel organic pada prosesnya akan terbentuk Gas CO2 dan H2O. Kedua senyawa tersebut akan bereaksi berturut-turut dengan?* In the experiment, the quantitative elements C and H on organic samples will form gases CO2 and H2O. Both compounds will react successively with?	*0,3 g senyawa organik menghasilkan 30 cm3 gas nitrogen pada tekanan 290 °K dan 745 mm. Hitung persentase nitrogen menggunakan metode Dumas. (diketahui, tegangan udara pada 290 °K = 12,7 mm)* 0.3 g of organic compounds produce 30 cm3 of nitrogen gas at 290 °K and 745 mm pressure. Calculate the nitrogen percentage using the Dumas method. (known, air voltage at 290 °K = 12.7 mm)

Table 3. Item of the Questionnaire "Reading time and Perception of Student's Difficulties during the Implementation of the RADEC Learning Model"

No.	Question	Type	Answer Choices
1	Have you read the readings given?	Closed-ended	Yes/No
2	How long have you been reading the material?	Closed-ended	30 minutes/ 60 minutes/ 120 minutes
3	What material is difficult to understand from the reading material?	Open-ended	-
4	What caused you to have trouble with the material?	Open-ended	-
5	What kind of difficulties did the brother encounter with the material?	Open-ended	-
6	Then, what alternative solutions do you use to minimize the obstacles you're experiencing?	Open-ended	-
7	Doing a "Read" before class can help you overcome the difficulties?	Open-ended	-
8	Is it by doing "Answer" to the question given by the lecturer before the lecture?	Open-ended	-
9	Can the "Discuss" of the issues given during the lecture help the brother overcome the difficulties?	Open-ended	-
10	Is it making an "Explain" of the solution/answer that can help you overcome the difficulties during the lecture?	Open-ended	-
11	Does the task of "Create" the reaction mechanisms given in the lectures help you overcome the difficulties?	Open-ended	-

Quantitative data from test instruments is analyzed using inferential statistical techniques (N-gain). In contrast, qualitative data is obtained from non-test instruments analyzed using triangulation methods, including data reduction, data presentation, conclusion withdrawal, and data verification to obtain representative research results. Table 4 shows the categories of the N-gain test as follows.

Table 4. N-Gain Test Category

N-Gain Score	Category
> 0.7	High
0.3 < N-gain < 0.7	Medium
< 0.3	Low

3. RESULT AND DISCUSSION

Result

One of the topics discussed in the Monofunctional Organic Chemistry course is Qualitative and Quantitative Analysis of Organic Compound Elements. Some concepts need to be comprehensively understood: Kjeldahl's concepts of matter, Dumas, Lassaigne destruction, distillation, and titration. Regarding learning Monofunctional Organic Chemistry, this study applies the RADEC learning model (Read, Answer, Discuss, Explain, and Create). Based on inferential analysis of data scoring pretest and posttest, the result was that there was an improvement in the medium category in understanding the concept of monofunctional organic chemistry, the subject matter of qualitative and quantitative analysis of elements of organic compounds, with N-gain value of 0.34 (Table 5).

Table 5. N-Gain Score of Pretest-Posttest regarding Conceptual Understanding on Qualitative and Quantitative Analysis of Organic Compound Elements

	N	Minimum	Maximum	Mean	Std. Deviation
N-Gain_Score	28	-.65	.88	.3431	.41614
N-Gain_Percentage	28	-65.00	87.50	34.3107	41.61427
Valid N (listwise)	28				

Furthermore, the results of the descriptive analysis showed that the average student's pretest score was 63.20, and the standard deviation was 18.98. The result obtained from the average posttest student score was 79.25, and the standard deviation was 12.02. As for the data on the pretest and posttest results, it can be concluded that the defaults of the deviation are smaller than the mean (average), so the data is homogeneous. Figure 2 shows the relationship between average scores and standard deviations on students' pretest and posttest.

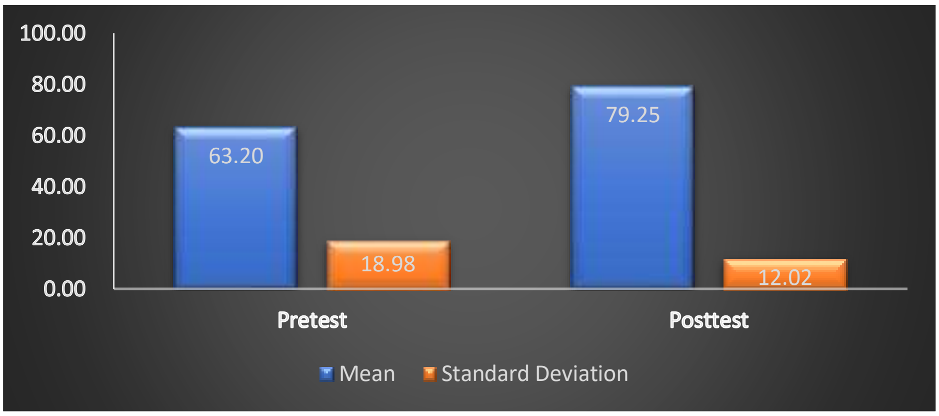
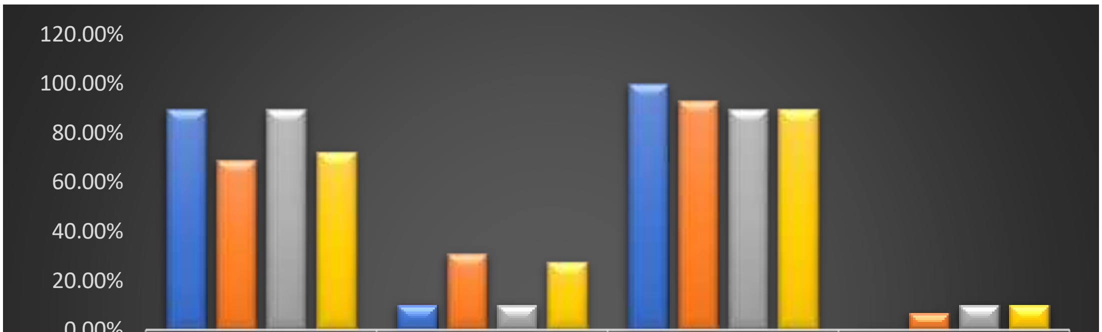


Figure 2. Mean score and standard deviation on pretest and posttest on qualitative and quantitative analysis of organic compound elements

Specifically, the pretest results showed that 89.66% of students answered correctly the first question, which is related to the history of organic chemistry development. Of the 68.97% of the students responded rightly to the second question, the question concerning the chemical properties of the organic compounds examined from the structure properties total of 89.66% of the students answered correctly on number 3 on the differences in the qualitative and quantitative analysis of organic compounds, and 72.41% on number 4 on the analysis of the elements C, H, O of the organic sample.

Next, the posttest results showed that as many as 100% of students answered correctly on number 1 on differential analysis based on chemical reactions. As many as 93.10% of students responded right on number 2 on qualitative analysis of function groups with chemicals. As much as 89.66% of the students responded true to number 3 on the history of the evolution of organic chemistry. And so many as 89,66% were correct on number 4 related to quantitative analysis of elements on organic compound samples. Figure 3 shows the percentage of pretest and posttest scores based on question items.



	Pretest (Correct Answer)	Pretest (Wrong Answer)	Posttest (Correct Answer)	Posttest (Wrong Answer)
Item 1	89.66%	10.34%	100.00%	0.00%
Item 2	68.97%	31.03%	93.10%	6.90%
Item 3	89.66%	10.34%	89.66%	10.34%
Item 4	72.41%	27.59%	89.66%	10.34%

Figure 3. Percentage of pretest and posttest scores based on the questions

Based on the analysis carried out on the application SPSS version 25.0.0.1 obtained, the results are listed in Table 5. On the pretest result, the minimum score for students in answering questions is 20.25, and the maximum score is 89.25. The posttest results show that the minimum score is 58.75, and the maximal score is 93.75. The data showed that there were differences in the student's conceptual understanding of the organic compound element analysis material before and after the given learning model of RADEC, which means there was an influence of the RADEC learning model on the improvement of students' conceptual comprehension of the organic chemistry course.

Table 6. Descriptive Statistical Data of the SPSS Application Version 25.0.0.1

		Pretest	Posttest
N	Valid	28	28
	Missing	0	0
Mean		63.1964	79.2500
Std. Error of Mean		3.58666	2.27208
Std. Deviation		18.97883	12.02274
Variance		360.196	144.546
Minimum		20.25	58.75
Maximum		89.25	93.75
Sum		1769.50	2219.00

Several obstacles trigger lower pretest scores than posttest, including the long duration of student reading before the learning process begins. Descriptive statistical data (figure 4) shows that 38% of students stated through a questionnaire that they had 30 minutes to read lecture material before learning started, 33.33% of students read lecture material for 60 minutes before learning began, and 28.57% read for 120 minutes. The data suggests that most students have an extended portion of reading lessons for 30 minutes.

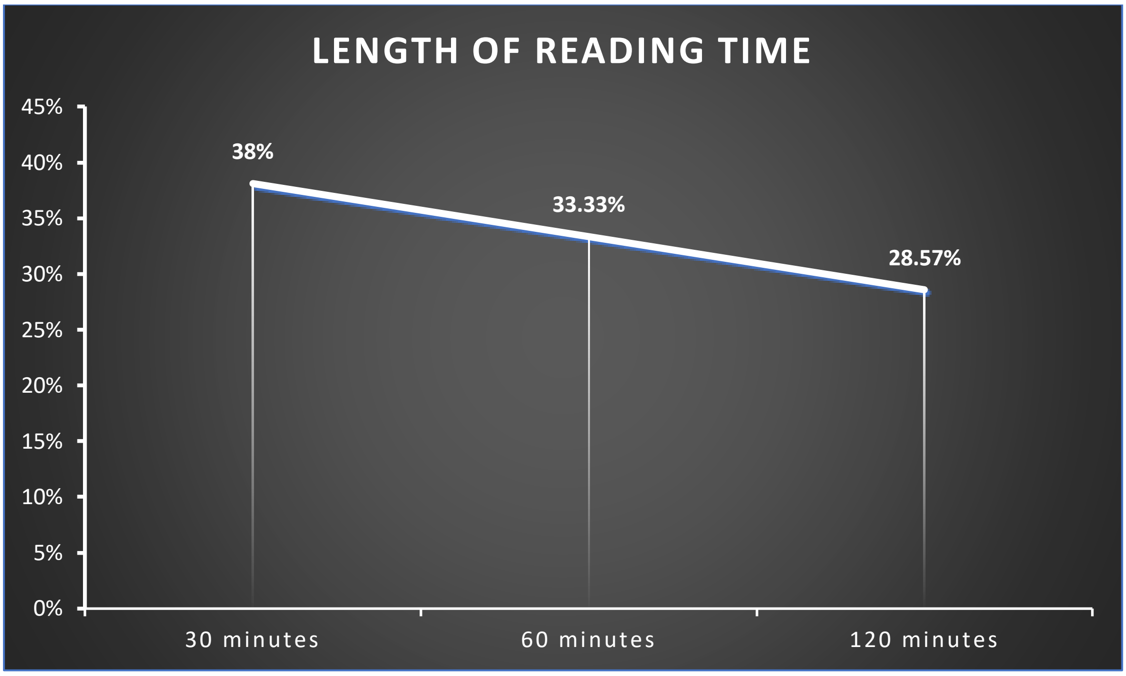


Figure 4. Data results from length of reading time

After the posttest was carried out, it continued excavating information about student learning difficulties on the Qualitative and Quantitative Analysis of Organic Compounds Elements (Figure 5). Then obtained results from the dissemination of the questionnaire to 21 students who volunteered to participate, that is, as much as 28% (6 students) stated having difficulties with the Kjedhal material, 24% (5 students) had problems with the Dumas material, 5% (1 student) had trouble with Lassaigne's destruction material; 5% (1 student) having difficulty with destruction, distillation, and titration; 9% (2 students) said they had problems with Kjeldahl and Dumas; 24%(5 students) had difficulties other than Kjeldall, Dumas, Lassaigne, distilling and titrating; and 5% (one student) said that they had no difficulty.

Discussion

The implementation of the RADEC learning model is used in this research because it can facilitate students to learn actively, not only mastering the learning concepts learned but also training skills and attitudes comprehensively (Lestari et al., 2022; Lestari, Sopandi, et al., 2021). “Read” activities in the RADEC model positively impact students because, through reading activities, students construct their knowledge and understanding independently so that during the learning process, students already have a supply of knowledge of the learning material (Lestari et al., 2020). Through this challenge, students become motivated to study books and gather information from other sources that will further help students understand the concepts of the material they will be studying (Hakim et al., 2016). “Read” activities are guided by pretest questions that contain many questions addressed to students to be answered because answers are essential cognitive concepts that students must master after studying a subject (Sukardi et al., 2021). Vygotsky's theory guides the “read” activity that through independent reading activities, a child (student) can dig information himself without the help of others (prior knowledge), and when they lack information by just reading, they can ask other students (equal tutors) or when explained at learning meetings. This activity will trigger the student's cognitive development to be in the Zone of Proximal Development (ZPD), where when the student is in the zone, then the student can develop his knowledge to think at a higher level to be able to provide alternative problem solving of the given issue (Fani & Ghaemi, 2011; Handayani et al., 2019; Sopandi & Handayani, 2019).

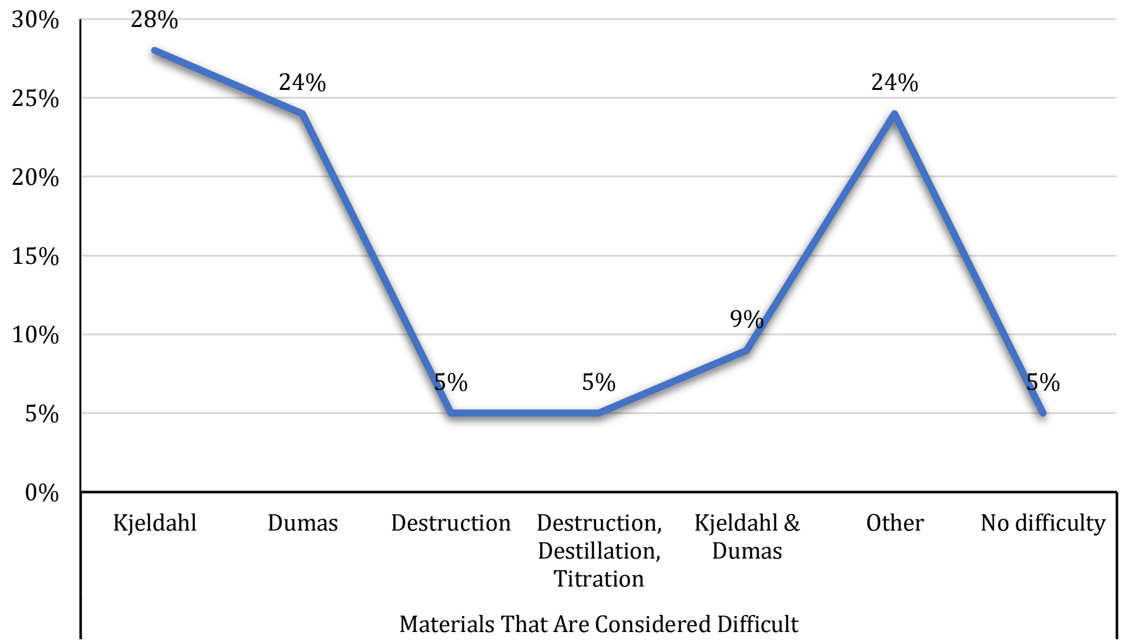


Figure 5. Results of difficulty learning in quantitative and qualitative analysis of elements of organic compound

Lecturers encourage students to answer pre-learning questions as a pretest depending on their understanding of reading (Lestari, Ali, et al., 2021; Lestari, Sopandi, et al., 2021). At this stage, students are also trained to build initiative and character or independence to find answers based on the sources of information they read (Rahmadani et al., 2021). The "answer" activity aims to show that before learning begins, students understand the learning material well so that the subsequent learning process can be focused on things that students do not understand, impacting effective learning (Pratama et al., 2019).

The information found at this study's "answer" stage improved the understanding of monofunctional organic chemistry topics of qualitative and quantitative analysis of organic compound elements in the medium category (N-gain 0.34). The average student's pretest score was 63.20, with a standard deviation of 18.98, and the average student's posttest score was 79.25 with 12.02. The low duration of student reading on qualitative and quantitative analysis of organic compound elements is one of the factors affecting the low achievement of students' understanding of concepts during pre-learning. Based on the survey results, the student's understanding of the concept of research belonging to the medium does not reach the high category due to some internal factors that exist within the student, i.e., difficulty understanding the material.

Difficulty understanding the material experienced can trigger a low enthusiasm and motivation for learning, ultimately affecting the low duration of students reading relevant material. In this study, the duration of students' reading material of the most dominant was only 30 minutes. Several researchers have researched the relationship between reading and learning motivation and found a significant moderate relationship between learning motivations and the reading activity of the students (Toste et al., 2020; Vernet et al., 2021). Vernet et al. (2021) also stated that reading is essential in the learning process, from literature to science; therefore, it must be possible for students to increase their motivation to read, which can ultimately affect their learning motivation.

The highest percentage of correct answers, namely 89.66%, during the pretest occurred in questions 1 and 3 on the subtopic of the history of the development of organic chemistry and the differences between qualitative and quantitative analysis of organic compounds. These two subtopics have a symbolic nature that is more focused on memorization, so students still find them easy because they do not require a high level of understanding. In introductory chemistry courses, significantly more students could solve problems using symbols and numbers than could describe particles in microscopic form. Students tend to excel at symbolic problem solving due to the structured nature of symbolic representations, which are often emphasized in chemistry education (McCollum et al., 2016).

Item number two on the chemical properties of organic compounds got the highest percentage of 31.03% as an item that many students answered incorrectly. In the posttest, 100% of students answered correctly that item number one was related to differences in analysis based on chemical reactions. In comparison, 10.34% of students replied incorrectly to item numbers 3 and 4 in a row, which was associated with the history of organic chemistry development and the quantitative analysis of elements on organic compound samples. However, overall, there was an increase in the percentage of correct answers by students and a decrease in the proportion of incorrect replies at the time of the posttest.

There are seven subtopics based on the analysis of students' learning difficulties in understanding the Element Analysis of Organic Compounds material in this research. Kjeldahl is the material subtopic that received the most votes and was selected as complex material. Two students were asked to give their opinions on why they experienced difficulties with this subtopic through an open questionnaire. The first student said that he did not deepen his understanding of the material during the pre-learning or the learning process, especially the methods used and the calculation mechanisms presented in the video during the learning process. In line with the first student, the second student also stated difficulty understanding the video shown regarding the process of implementing the Kjeldahl method. Kjeldahl's method is a method for determining Nitrogen that was discovered in 1883 by a scientist named Kjildahl (Gautam et al., 2023; Sáez-Plaza, Michałowski, et al., 2013; Sáez-Plaza, Navas, et al., 2013). Kjeldahl's method has three main steps: sample destruction, distillation, and ammonia determination (Sáez-Plaza, Navas, et al., 2013).

Furthermore, the Dumas sub-topic is in the second order after Kjeldahl, which is problematic. Dumas is an alternative to the Kjeldahl method for determining protein in foods (Muñoz et al., 2018). The principle of this method is based on the burning of the sample at high temperatures and, at the final stage, converted into N_2 gas, which is subsequently captured by the detector into % nitrogen or protein (Ebeling, 1968; Shea et al., 1933). The responses of two students who volunteered to provide information about the difficulties they encountered on the sub-topic were excavated, thus obtaining the analysis result that they had difficulty understanding the principles of the Dumas method and performing calculations to find the percentage of Nitrogen in the sample. Difficulty is often experienced in getting accurate results when determining Nitrogen by the Duma method; errors are sometimes caused by the burning of samples too quickly and by the carbon dioxide detector (Shea et al., 1933).

The difficulty of understanding the processes of Kjeldahl and Dumas methods can occur because the student being the sample is a first-year student in undergraduate school, so the sub-topic about Kjeldahl and the Dumas is not so familiar to them that it is considered problematic. When students are confronted with new learning and material situations with too much to be dealt with in their limited workspace, they will have difficulty choosing the vital information in the material they offer (Sirhan, 2007).

In addition to the various factors causing student learning difficulties on the presented Organic Compound Analysis material, respondents also acknowledged that the Read, Answer, Discussion, Explain, and Create (RADEC) learning stages can help them in alleviating and overcoming learning difficulty that occurs during learning. Many researchers defined learning concepts in science subjects and tested the influence of different teaching methods and techniques on student success in science and addressing their misconceptions. The researchers stressed the need to use different approaches, strategies, methods, and teaching techniques in science education (Kaçar & Balim, 2021); one of them is the RADEC learning model used in this study.

4. CONCLUSION

Enhanced understanding of the student's concepts in the Monofunctional Organic Chemistry course on the quantitative and qualitative analysis of organic compound elements showed an N-Gain score of 0.34 which belongs to the medium. Several factors influenced the student's poor understanding of the concepts stated by 28.6% of students claiming to have difficulty understanding concepts on Kjeldahl material, 23.8% difficulty on Dumas material, 4.76% difficulties on Lassaigne destruction material, 4,76% difficulty in Kjildahl and Dumas materials, and 1% difficulty with destruction, distillation, and titration material. A total of 23.8% of students submitted difficulties because they did not understand the question's meaning, the lesson material's submission, and the writing of the reaction equations. Nevertheless, the RADEC learning model can help overcome learning difficulties that occur during learning based on survey results. Other data suggest that students' difficulties are due to a lack of reading before attending classes. Difficulty understanding the material experienced can trigger a low enthusiasm and motivation for learning, ultimately affecting the low duration of reading. Only 28.57% of students read for 2 hours, 33.33% read for 1 hour, and 38% read for 0.5 hours.

5. ACKNOWLEDGE

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6. REFERENCES

Alao, S., & Guthrie, J. T. (1999). Predicting conceptual understanding with cognitive and motivational variables. *Journal of Educational Research*, *92*(4), 243–254. https://doi.org/10.1080/00220679909597602

Creswell, J. W., & Clark, V. L. P. (2018). *Designing and Conductiving Mixed Methods Research* (Third). SAGE Publications.

Ebeling, M. E. (1968). The Dumas Method for Nitrogen in Feeds. *Journal of AOAC INTERNATIONAL*, *51*(4), 766–770. https://doi.org/10.1093/jaoac/51.4.766

Fani, T., & Ghaemi, F. (2011). Implications of Vygotsky's Zone of Proximal Development (ZPD) in Teacher Education: ZPTD and Self-Scaffolding. *Procedia - Social and Behavioral Sciences*, *29*(Iceepsy), 1549–1554. https://doi.org/10.1016/j.sbspro.2011.11.396

Gautam, V. P., Mishra, S., & Ahmed, H. (2023). Comparison of Total Nitrogen estimation by Kjeldahl Method and CHNS Analyzer in Dry Tropical Grassland. *International Journal of Plant and Environment*, *9*(02), 180–182. https://doi.org/10.18811/ijpen.v9i02.13

Gupte, T., Watts, F. M., Schmidt-Mccormack, J. A., Zaimi, I., Gere, A. R., & Shultz, G. V. (2021). Students' meaningful learning experiences from participating in organic chemistry writing-to-learn activities. *Chemistry Education Research and Practice*, *22*(2), 396–414. https://doi.org/10.1039/d0rp00266f

Hakim, A., Liliasari, Kadarohman, A., & Syah, Y. M. (2016). Effects of the natural product mini project laboratory on the students conceptual understanding. *Journal of Turkish Science Education*, *13*(2), 27–36. https://doi.org/10.12973/tused.10165a

Handayani, H., Sopandi, W., Syaodih, E., Suhendra, I., & Hermita, N. (2019). RADEC: An Alternative Learning of Higher Order Thinking Skills (HOTs) Students of Elementary School on Water Cycle. *Journal of Physics: Conference Series*, *1351*(1). https://doi.org/10.1088/1742-6596/1351/1/012074

Kaçar, S., & Balim, A. G. (2021). Investigating the Effects of Argument-Driven Inquiry Method in Science Course on Secondary School Students' Levels of Conceptual Understanding. *Journal of Turkish Science Education*, *18*(4), 816–845. https://doi.org/10.36681/tused.2021.105

Lestari, H., Ali, M., Sopandi, W., & Wulan, A. R. (2021). Infusion of Environment Dimension of ESD into Science Learning Through the RADEC Learning Model in Elementary Schools. *Jurnal Penelitian Pendidikan IPA*, *7*(SpecialIssue), 205–212. https://doi.org/10.29303/jppipa.v7ispecialissue.817

Lestari, H., Ali, M., Sopandi, W., Wulan, A. R., & Rahmawati, I. (2022). The Impact of the RADEC Learning Model Oriented ESD on Students' Sustainability Consciousness in Elementary School. *Pegem Egitim ve Ogretim Dergisi*, *12*(2), 113–122. https://doi.org/10.47750/pegegog.12.02.11

Lestari, H., Setiawan, W., & Siskandar, R. (2020). Science Literacy Ability of Elementary Students Through Nature of Science-based Learning with the Utilization of the Ministry of Education and Culture's "Learning House." *Jurnal Penelitian Pendidikan IPA*, *6*(2), 215. https://doi.org/10.29303/jppipa.v6i2.410

Lestari, H., Sopandi, W., Sa'ud, U. S., Musthafa, B., Budimansyah, D., & Sukardi, R. R. (2021). The impact of online mentoring in implementing radec learning to the elementary school teachers' competence in training students' critical thinking skills: A case study during covid-19 pandemic. *Jurnal Pendidikan IPA Indonesia*, *10*(3), 346–356. https://doi.org/10.15294/JPII.V10I3.28655

Lopez, E., Kim, J., Nandagopal, K., Cardin, N., Shavelson, R. J., & Penn, J. H. (2011). Validating the use of concept-mapping as a diagnostic assessment tool in organic chemistry: Implications for teaching. *Chemistry Education Research and Practice*, *12*(2), 133–141. https://doi.org/10.1039/c1rp90018h

Mackey, K., McHugh, M., & McGlacken, G. P. (2022). Some people and personalities of organic chemistry: A teaching hook for mid-level university students. *Chemistry Teacher International*, *4*(4), 327–338. https://doi.org/10.1515/cti-2021-0037

McCollum, B., Sepulveda, A., & Moreno, Y. (2016). Representational technologies and learner problem-solving strategies in chemistry. *Teaching and Learning Inquiry*, *4*(2). https://doi.org/10.20343/teachlearninqu.4.2.10

Muñoz, D., Ballesteros, M. M., & Santiago, M. (2018). Validation of the Dumas Method for the Determination of Proteins in Foods. *Biosaia*, *7*(4), 10843.

Nieswandt, M. (2007). Student affect and conceptual understanding in learning chemistry. *Journal of*

Research in Science Teaching, *44*(7), 908–937. https://doi.org/10.1002/tea.20169

O'Dwyer, A., & Childs, P. E. (2017). Who says organic chemistry is difficult? Exploring perspectives and perceptions. *Eurasia Journal of Mathematics, Science and Technology Education*, *13*(7), 3599–3620. https://doi.org/10.12973/eurasia.2017.00748a

Pratama, Y. A., Sopandi, W., & Hidayah, Y. (2019). RADEC Learning Model (Read-Answer-Discuss-Explain And Create): The Importance of Building Critical Thinking Skills In Indonesian Context. *International Journal for Educational and Vocational Studies*, *1*(2), 109–115. https://doi.org/10.29103/ijevs.v1i2.1379

Rahmadani, D., Chastanti, I., & Harahap, D. A. (2021). Parents' Role in Biology Learning During the Covid 19 Pandemic. *Jurnal Penelitian Pendidikan IPA*, *7*(2), 137. https://doi.org/10.29303/jppipa.v7i2.583

Reid, N., & Shah, I. (2007). The role of laboratory work in university chemistry. *Chemistry Education Research and Practice*, *8*(2), 172–185. https://doi.org/10.1039/B5RP90026C

Rosly, N. N., Hamid, S. A., & Rahman, N. A. A. (2021). Exploring the Perception of Chemistry Students at Kulliyyah of Science in Learning Organic Chemistry. *IIUM Journal of Educational Studies*, *9*(2), 6–30. https://doi.org/10.31436/ijes.v9i2.299

Sáez-Plaza, P., Michałowski, T., Navas, M. J., Asuero, A. G., & Wybraniec, S. (2013). An Overview of the Kjeldahl Method of Nitrogen Determination. Part I. Early History, Chemistry of the Procedure, and Titrimetric Finish. *Critical Reviews in Analytical Chemistry*, *43*(4), 178–223. https://doi.org/10.1080/10408347.2012.751786

Sáez-Plaza, P., Navas, M. J., Wybraniec, S., Michałowski, T., & Asuero, A. G. (2013). An Overview of the Kjeldahl Method of Nitrogen Determination. Part II. Sample Preparation, Working Scale, Instrumental Finish, and Quality Control. *Critical Reviews in Analytical Chemistry*, *43*(4), 224–272. https://doi.org/10.1080/10408347.2012.751787

Salame, I. I., Casino, P., & Hodges, N. (2020). Examining Challenges that Students Face in Learning Organic Chemistry Synthesis. *International Journal of Chemistry Education Research*, *4*(April), 1–9. https://doi.org/10.20885/ijcer.vol4.iss1.art1

Salame, I. I., Patel, S., & Suleman, S. (2019). Examining Some of The Students' Challenges in Learning Organic Chemistry. *International Journal of Chemistry Education Research*, *3*(June), 6–14. https://doi.org/10.20885/ijcer.vol3.iss1.art2

Shea, F., Watts, C. E., Corporation, C. S., & Haute, T. (1933). Dumas Method for Organic Nitrogen Methods of Representing Distribution of Particle Size. *Industrial and Engineering Chemistry Analitical*, *11*(6), 333–334.

Sibomana, A., Karegeya, C., & Sentongo, J. (2021). Students' conceptual understanding of organic chemistry and classroom implications in the Rwandan perspectives: A literature review. *African Journal of Educational Studies in Mathematics and Sciences*, *16*(2), 13–32. https://doi.org/10.4314/ajesms.v16i2.2

Siregar, L. S., Wahyu, W., & Sopandi, W. (2020). Polymer learning design using Read, Answer, Discuss, Explain and Create (RADEC) model based on Google Classroom to develop student's mastery of concepts. *Journal of Physics: Conference Series*, *1469*(1). https://doi.org/10.1088/1742-6596/1469/1/012078

Sirhan, G. (2007). Learning Difficulties in Chemistry: An Overview. *Journal of Turkish Science Education*, *4*(2), 2–20.

Sopandi, W. (2017). The quality improvement of learning processes and achievements through the read-answer-discuss-explain-and create learning model implementation. *Proceeding 8th Pedagogy International Seminar 2017: Enhancement of Pedagogy in Cultural Diversity Toward Excellence in Education*, *8*(229), 132–139.

Sopandi, W., & Handayani, H. (2019). *The Impact of Workshop on Implementation of Read-Answer-Discuss-Explain-And-Create (RADEC) Learning Model on Pedagogic Competency of Elementary School Teachers*. *178*(ICoIE 2018), 7–11. https://doi.org/10.2991/icoie-18.2019.3

Sukardi, R. R., Sopandi, W., & Riandi, R. (2021). Repackaging RADEC Learning Model into the Online Mode in Science Class. *Journal of Physics: Conference Series*, *1806*(1). https://doi.org/10.1088/1742-6596/1806/1/012142

Toste, J. R., Didion, L., Peng, P., Filderman, M. J., & McClelland, A. M. (2020). A Meta-Analytic Review of the Relations Between Motivation and Reading Achievement for K–12 Students. *Review of Educational Research*, *90*(3), 420–456. https://doi.org/10.3102/0034654320919352

Vernet, M., Bellocchi, S., Leibnitz, L., Chaix, Y., & Ducrot, S. (2021). Predicting Future Poor Readers from Pre-reading Visual Skills: A Longitudinal Study. *Applied Neuropsychology: Child*, *0*(0), 1–15. https://doi.org/10.1080/21622965.2021.1895790

Zhu, S., Morkan, B., & Yan, Z. (2023). Young geniuses versus old masters: Two different trajectories of individual knowledge bases in the innovation process. *Knowledge and Process Management*, *30*(1), 55–64. https://doi.org/10.1002/kpm.1733