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Correlation Profile of Cognition Levels and Student Ability to Solve Problems in Biodiesel Synthesis

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Abstract: Covid-19 has had a huge impact in all sectors. The socio-economic sector experienced the heaviest impact. One of the sectors affected is the world of education. Education is now transforming from face-to-face learning to online learning. Online learning is very helpful for students during covid-19. In addition to having a positive value, online learning also contains a negative value. For example, students' interest in reading increases, but on the other hand, students' reading power is low. Low reading power has an impact on decreasing the cognitive level of students. The purpose of this research is to first identify the cognitive level profiles and students' abilities in solving problems in the synthesis of biodiesel from used cooking oil. Analyzing the correlation between cognitive level and students' ability to solve problems. This research is a correlational descriptive research. This research was conducted on fourth semester chemistry education students who were taking an instrument chemistry course and determining the structure of organic compounds. Cognitive level and problem-solving ability were measured using a rubric for assessing cognitive level and student problem-solving ability. The data obtained is then described in graphical form. The data was then tested for correlation using the SPSS product moment correlation test. In this study, it was found that the cognitive level of most students entered at C2 and C3 levels and the average problem solving ability was 53.84. The results of the correlation test show that the cognitive level is positively correlated with the ability of students to solve problems. This is evidenced by the comparison of the value of r count 0.724> r table 0.44. Based on the results of this study, it can be concluded that the cognitive level and problem solving abilities of students are still low. Cognitive level and problem solving ability are positively correlated.

Keywords: Cognitive level; Problem solving abilities

Introduction

Online learning is a learning technique that utilizes technology in the learning process. Online learning is categorized into three Synchronous Learning, Asynchronous Learning, and Blended Learning. This learning technique is very helpful, especially during a pandemic. Learning trains student independence and reduces interactions with other people. This technique has many positive sides but contains negative sides. Many students complain about difficulties in constructing their understanding, especially in abstract concepts. Chemical concepts are one example of a concept that contains many abstract concepts. Abstract concepts need to be realised through laboratory work and studied computationally (Seery, 2020). Abstract chemical concepts containing multiple levels of representation must be conveyed using a variety of learning techniques (Safitri et al., 2019).

Online learning that has not combined laboratory science activities with multilevel chemistry reference studies has an impact on students' low cognitive levels (Quattrucci, 2018). The findings of online learning researchers, especially at the start of the pandemic, were very conventional. Many materials are transferred via whatshap and email. This happens because of the low IT

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literacy of teachers and lecturers. This problem has an impact on students who have just entered college in the middle of 2019. The basic theoretical concepts that form the foundation of knowledge for higher level courses are not well developed. As a result, students have difficulties in studying chemistry at a higher level and are applied in nature. Especially in chemistry material, where almost all of the content is abstract, students complain about online learning processes that are difficult to understand, especially in subjects that contain chemical concepts and are multirepresentative (Ismail, 2020; Kawamura, 2019). In order to be able to understand the content criteria students must have critical thinking skills (Abdurrahman et al., 2019).

Online learning that does not combine theoretical concepts and content characteristics with multiple representations has a negative impact on increasing students' thinking levels (Abduljabbar et al., 2015; Huilan et al., 2020; Saputra et al., 2019; Siswanto et al., 2019). Apart from having an impact on the cognitive level of online learning, it also builds student bad character. One of the bad characters that appears is the low reading power of students. Learning models that train students in developing thinking skills need to be continuously developed. Belluigi et al. (2017), Dunne (2015), Eyisi (2016) and Reynders et al. (2019) reported that laboratory scientific activities were able to improve data processing abilities, managerial skills and critical thinking skills (Ilyana et al., 2015). So learning chemistry cannot be separated from scientific processes in the laboratory. This process is proven to be able to train students in improving their ability to solve problems. The problem-based learning model is reported to be able to improve students' thinking skills and creativity in solving problems (Pohan et al., 2020; Suradika et al., 2023).

Problem-based learning (PBL) is an educational approach that has been widely recognized for its effectiveness in enhancing students' thinking skills and fostering creativity in problem-solving. PBL is a student-centered instructional method in which learners actively engage in solving real-world problems or case studies. Instead of traditional teacher-led instruction, students take on an active role in identifying problems, conducting research, collaborating with peers, and proposing solutions (Choi et al., 2014; Peck et al., 2016). PBL encourages students to think critically by analyzing and evaluating information to develop problem-solving strategies. They learn to question assumptions, gather evidence, and make informed decisions, which strengthens their ability to think critically (Yu et al., 2015).

Through PBL, students encounter complex and open-ended problems that require them to apply their knowledge and skills creatively. They learn to break down problems into manageable parts, consider different perspectives, and devise innovative solutions. PBL often involves collaborative group work, where students work together to solve problems. This promotes effective communication, cooperation, and teamwork skills, as they learn to share ideas, negotiate, and build on each other's contributions (Ali, 2019; Valdez et al., 2019). PBL encourages students to think creatively and generate unique solutions to problems. By exploring different possibilities and considering multiple perspectives, they develop their ability to think outside the box and come up with innovative approaches (Baptista et al., 2019). PBL fosters self-directed learning skills as students take responsibility for their own learning process. They develop research skills, independent thinking, and the ability to seek out resources and information, which are valuable skills in problem-solving and lifelong learning.

The problem-based learning model provides an active and engaging learning environment that stimulates students' thinking skills, promotes creativity, and prepares them for real-world challenges. The problem-based learning model combined with laboratory activities needs to be designed as well as possible to increase students' cognitive level. The process of cognitive development must be intact which involves a process of integrating the level of abstraction with the concrete (Miterianifa et al., 2019; Setiani et al., 2020; Suparman et al., 2021). This process trains reasoning and draws conclusions based on observed problems and empirical data obtained from scientific activities in laboratories (Amïn et al., 2020; Ghani et al., 2017; Hidayat et al., 2019). Practicing students' thinking skills needs to be continuously developed. Higher-order thinking skills are the demands of the 21st century (Ghani et al., 2017; Ricaurte et al., 2020; Sholihah et al., 2020; Suradika et al., 2023). An adaptive style of thinking in seeing the problems around is very much needed in the midst of such a dynamic development of the times (Ichsan et al., 2019). Increased thinking skills can be continuously grown through contextual, problem-based learning combined with scientific activities in the laboratory (Malik et al., 2021).

Ince (2018) and Neubert et al. (2015) report One of the skills that is needed in the 21st century is the ability to solve problems. Problem-solving skills are highly valuable in the 21st century. The rapid pace of technological advancements and the complex challenges faced in various domains require individuals who can effectively analyze problems and develop innovative solutions. Here are some reasons why problem-solving skills are crucial in the 21st century (El-Zein et al., 2016; Fruyt et al., 2015; Szabo et al., 2020).

The world is constantly changing, and new problems arise regularly. Individuals with strong problem-solving skills can quickly adapt to new situations, identify the root causes of problems, and find creative solutions (Nakakoji et al., 2020; Sholihah et al., 2020). Problem-solving often involves thinking outside the box and coming up with new ideas. The ability to generate innovative solutions is essential for driving progress and staying competitive in today's fast-paced world.

Kim et al. (2019), Rahman (2019) and Simamora et al. (2018) report complex problems often require collaboration and teamwork. Effective problem solvers can work well with others, communicate their ideas, and facilitate productive discussions to reach consensus and achieve common goals. Problem-solving involves critical thinking, which is the ability to objectively analyze information, evaluate different perspectives, and make informed decisions. Critical thinking helps individuals navigate the abundance of information available today and identify reliable sources (Falcó-Pegueroles et al., 2021; Fitriani et al., 2020). Problem-solving skills also involve resilience and the ability to persevere in the face of challenges and setbacks. The 21st century presents numerous obstacles, and individuals with problem-solving skills can adapt, learn from failures, and bounce back stronger.

As technology continues to advance, individuals need problem-solving skills to effectively integrate and utilize new tools and systems. Understanding how to leverage technology to solve problems efficiently is essential in today's digital age.

Learning based on students' contextual problems needs to be continuously developed to train students' thinking skills in solving problems more creatively (Khoiriyah et al., 2018; Muhali, 2019). The ability to solve problems is one indicator of increasing the cognitive level of students. Suhirman et al (2021) found that problem-based learning can improve students' critical thinking skills and curiosity, while natural intelligence has no effect on students' critical thinking skills and curiosity. Based on the description above, research using problem-based learning methods with a contextual approach based on national issues is important to do to improve students' cognitive levels and students' ability to solve problems state the objectives of the work and provide an adequate background, avoiding a detailed literature survey or a summary of the results.

Method

This research is a correlational descriptive research. This research was conducted on 4th semester chemistry education students who were taking a course on determining the structure of organic compounds. The variables measured in this study were students' cognitive level and problem-solving skills. Cognitive level is measured based on students' ability to explore problems, causes of problems, alternative solutions, plans for laboratory activities and the ability to understand the concept of biodiesel. The cognitive level measured is based on the concept discovered by Bloom. The ability to solve problems is measured includes seven components, namely using various procedures; manipulate; understand the concept; note similarities, differences and analogies; identify critical matters and select appropriate procedures; interpret the relationship of several variables (Onieva-Zafra et al., 2020; Seeram, 2019). Assessment is carried out during the planning process and practicum activities take place. The data obtained was then described in graphical form and analyzed for correlation using the SPSS moment product correlation technique.

Result and Discussion

The cognitive level of students is low. Online learning that is still conventional through whatsapp and zoom social media has a negative impact on student cognitive development. Online learning that does not emphasize scientific activity through laboratory practicum activities has an impact on students' ability to identify problems and find solutions to problems found. This low cognitive level is also caused by the lack of ability of chemistry students to understand basic chemical concepts. The basics of determining the structure of organic compounds is a course taught in Semester IV this course is a trepan course from organic chemistry and instrument chemistry courses. Basic chemical concepts such as chemical bonding and elemental chemistry are needed to develop the concept of light interaction with bonding and its implications for changes in the molecular structure of organic compounds. The implications of methods, approaches and low understanding of concepts can be seen from the low cognitive level of students as shown in Figure 1.

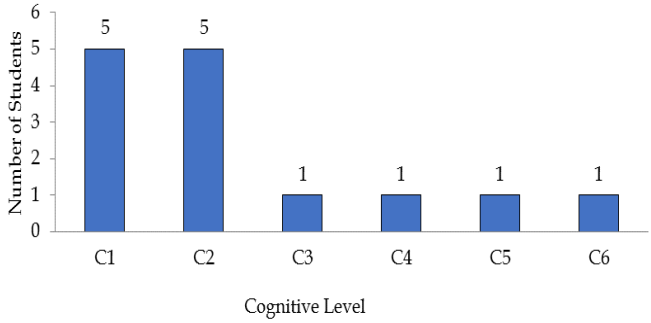

Figure 1. Profile of student's cognitive level

Cognitive level is measured based on students' ability to explore problems, causes of problems, alternative solutions, plans for laboratory activities and the ability to understand the concept of biodiesel. Based on graph 1 above, the average cognitive level of students is still low. The average cognitive level of students is still at levels 1 and 2. At this level students are at the cognitive level of memorizing and understanding. This level is also known as low-order thinking skills (LOTS) (Hayikaleng et al., 2016; Tsaparlis, 2020). Post-covid-19 pandemic student learning trends prefer online learning. The results showed that students' interest in reading was high but their reading power was low. Interest in reading is reflected in students' ability to access more diverse information from many sources. This is evidenced by the source references attached to the practicum report. Low reading power is a factor in decreasing cognitive levels (Ichsan et al., 2019; Johann et al., 2020; Ng et al., 2019). High reading power is shown by the ability to explore problems and provide appropriate solutions to the problems that have been mapped. The low cognitive level of students has an impact on students' ability to solve problems as shown in Figure 2.

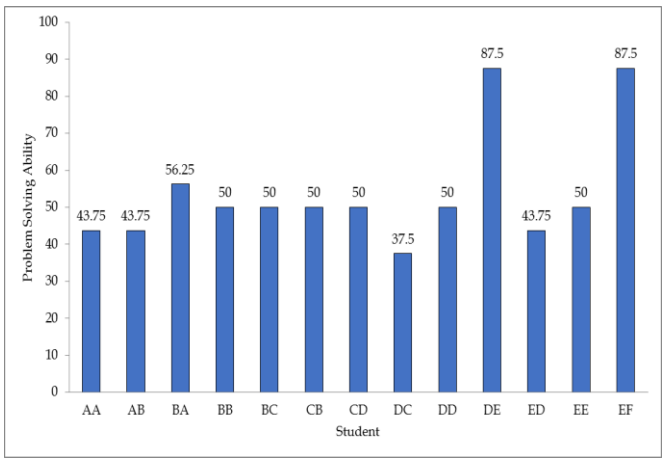

Figure 2. Problem solving ability

The ability to solve problems is also relatively low. If analyzed Figures 1 and 2 have a close relationship. Students with low cognitive levels have low problem solving abilities. A high cognitive level encourages students to be more dynamic in thinking (Kazemi et al., 2012). The ability to solve problems is more effective when done collaboratively. Collaboration from multiple sources will produce arguments that are more comprehensive and broad. The more complex the problem requires the more creative and innovative thinking.

Cognitive flexibility is needed in dealing with the complexity of problems. Covid-19, which has an impact on socio-economic problems, really requires additional skills to be able to adapt. Adaptive ability in dealing with complex problems can be grown by increasing the cognitive level. The higher the cognitive level will affect the proficiency in finding solutions to various problems encountered. Cognitive level refers to a person's mental capabilities, including their ability to perceive, process, and apply knowledge. It encompasses skills such as critical thinking, problem-solving, reasoning, and decision-making (Al-Khatib, 2019; Lysaker et al., 2020; Mitsea et al., 2021; Rahman, 2019).

Individuals with a higher cognitive level possess a range of cognitive skills and strategies that enable them to approach problems in a systematic and effective manner. They have the capacity to analyze complex situations, identify patterns, and generate creative solutions. They can draw upon their knowledge and past experiences to develop innovative approaches and adapt their problem-solving strategies to different contexts. Higher cognitive levels are often associated with advanced education, training, and experience. As individuals engage in activities that promote intellectual development and problem-solving skills, their cognitive abilities tend to improve. They acquire a broader knowledge base, develop more sophisticated thinking processes, and become adept at applying their knowledge to real-world problems.

Furthermore, individuals with higher cognitive levels typically exhibit greater metacognitive skills. Metacognition refers to the ability to reflect on and regulate one's own thinking processes. High cognitive level individuals are often better at monitoring their own thoughts, evaluating the effectiveness of their problem-solving strategies, and making adjustments as needed. They possess a higher level of self-awareness, enabling them to recognize biases, consider alternative perspectives, and make more informed decisions (Boogert et al., 2018; Sala et al., 2019). These results are in line with the findings of researchers that cognitive level is positively correlated with problem solving abilities as shown in Table 1.

Table 1. Cognitive Level Correlation Test Results with Problem Solving Abilities

		VAR00001	VAR00002
VAR00001	Pearson Correlation	1	.724**
	Sig. (2-tailed)		.005
	N	13	13
VAR00002	Pearson Correlation	.724**	1
	Sig. (2-tailed)	.005	
	N	13	13

Problem-based learning has not been able to significantly increase cognitive levels and problem-solving skills. This method needs to be familiarized so that students are familiar with the syntax. The findings

of student researchers are not used to identifying problems and exploring problems further to find appropriate alternative solutions. There is a very positive value in the application of problem-based learning models including students being able to find the meaning of learning that can generate motivation to learn. The problems studied in this learning activity are adapted to developing national issues. The problem of dwindling fossil energy sources is raised as the main problem in this lesson. Fossil energy is non-renewable energy. The increasing human population is increasingly having an impact on the world energy crisis because energy needs are increasing (Kreps, 2020). Students are expected to be able to open their horizons by looking at the resources found in their respective areas. Maximizing regional resources aims to hone students' abilities in seeing the potential of their respective regions.

The skill of seeing problems really needs to be continuously trained in prospective teachers so that creative and innovative teachers are formed in the midst of demands for higher quality education. Based on graph 2, the ability of students to solve problems is still relatively low. Students' habits with online learning slightly affect students' ability to identify local problems and materials that can be used as alternative renewable energy. Online learning that is done only transfers information through the Google class room or through the Zoom application causes low psychomotor activity. Problems that must be tested and studied through practicums are rarely done during a pandemic. This habit forms the character of students who find it difficult to follow the learning process with a scientific approach (Alawamleh et al., 2020; Johann et al., 2020; Ram et al., 2021). Lack of psychomotor activity has an impact on the lack of the brain's ability to process information properly. Ram et al. (2021) reports that online learning reduces student performance in participating in learning. The advantage of the problem-based learning model is that it can hone students' science process skills. The problem-based learning process with applied product orientation is proven to be able to improve student skills, especially the ability of students to make activated carbon and biodiesel. Based on the results of the biodiesel sample test using the GC-MS instrument, students were able to make biodiesel with 100% purity. These results increase students' learning motivation because learning with the product-oriented PBL method is able to create meaning in learning. One of the reasons for low learning motivation is that students have not found the meaning or benefits of learning about a scientific concept. The low ability of students at the cognitive level and ability to solve problems is caused by the low mastery of the basic concepts of chemistry which form the foundation for subsequent concepts. This is indicated by the ability of students to describe the flow of reactions for making biodiesel in Figures 3 and 4.

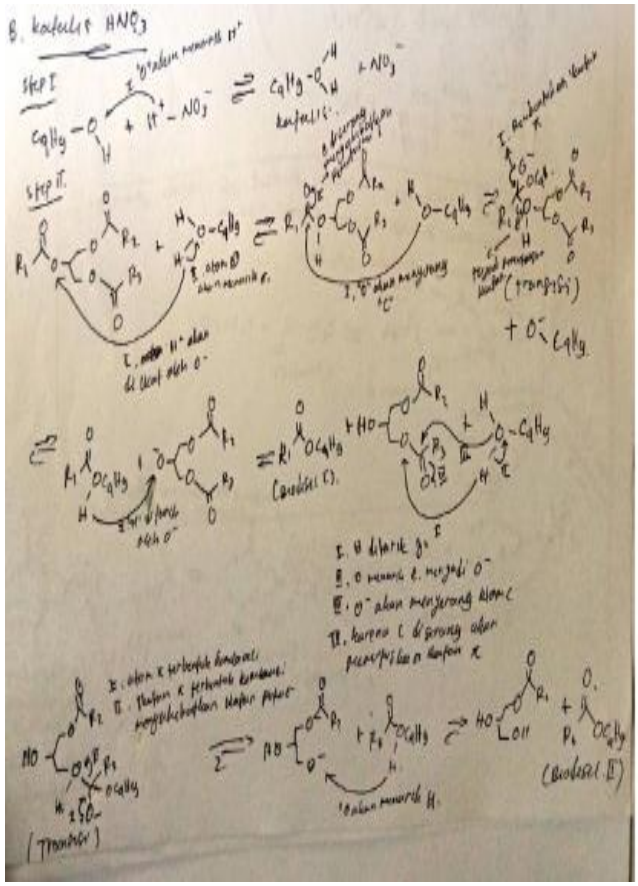

Figure 3. Student answers in the HOTS category

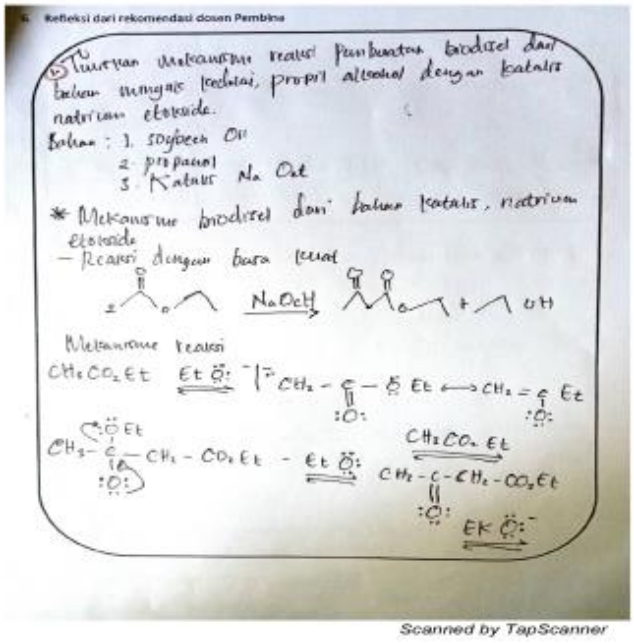

Figure 4. Student answers in the LOTS category

Figure 3 Describes students' ability to describe the reaction mechanism for making biodiesel from used cooking oil. Based on Figure 1, students with higher cognitive levels are shown to be able to describe the reaction mechanism more comprehensively. Students with a higher cognitive level are able to describe and tell a more complete reaction mechanism for making biodiesel. Based on Figure 1 students are able to describe and tell the mechanism of each stage of the reaction. Students are able to describe the direction and chemical charge contained in the reacting molecules. Students with lower cognitive levels are proven not to have mastered chemistry concepts well. It takes the ability to analyze the structure in describing the reaction flow. Student creativity in making storylines in a reaction shows a higher cognitive level. Analytical skills and story-telling skills reflect a higher level of thinking (Ichsan et al., 2019; Tsaparlis, 2020). The findings show that 71% of cognitive level students are categorized as LOTS and 29% HOTS. The low HOTS of students is reflected in their mistakes in writing down the molecular structure of the reacting compounds and their inability to describe the reaction accurately and their inability to analyze the spectrum of the results of the biodiesel sample test using the GC-MS instrument.

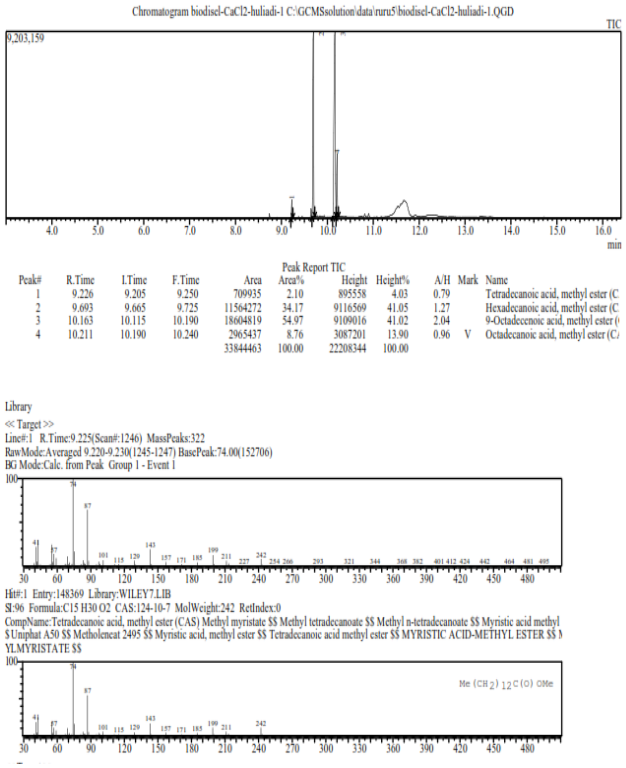

Figure 5. Chromatogram of biodiesel from used cooking oil

The cognitive level of students was also measured in analyzing the results of the biodiesel sample test using the GC-MS instrument shown in Figure 5. The ability of students to analyze GC-MS data is an indicator of students' cognitive level and ability to solve problems. Skills are required in reading data that describe the concentration of certain components in a sample. Skills in analyzing fragments are abilities needed by students in determining the structure of components that are fragmented into molecular ions. Students' ability to think critically is needed in interpreting GC-MS data. The ability to relate the initial mass of the ion molecule after going through electron bombardment is needed to be able to predict the structure. The initial molecular ion describes a molecule that loses one electron after going through electron bombardment (Kumar et al., 2014; Zhou et al., 2020). Most students can only read molecular ions based on the molecular mass listed on the spectrum and the % area which describes the concentration of the biodiesel component. Students have not been able to describe the events of the fragmentation of molecular ions into smaller molecular ions. Student skills in criticizing molecular ions are needed to be able to describe reduced molecular ions into smaller positive molecular ions (Kondyli et al., 2019).

Conclusion

Students average cognitive level and ability to solve problems is still low. The results of the correlation test show that the cognitive level is positively correlated with the ability of students to solve problems. This is evidenced by the comparison of the value of r count 0.724> r table 0.44. This relationship shows that if the student's cognitive level is high, the student's ability to solve problems will increase. The application of the product-oriented PBL model is able to increase learning demands and train the skills of prospective teachers in presenting contextual problems in learning.

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Author Contributions

[1&5]Author plays a role in building the theoretical conceptual basis for this research. [2&4]Author plays a role in designing research, learning tools and is responsible for designing this paper until it is published. [3]Author has the role of being a model lecturer and carrying out practicum activities in the Chemistry laboratory at the Mandalika University of Education and the Analytical Laboratory at the University of Mataram. [3]Author plays a role in conducting data analysis and data interpretation.

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Research conducted independently. Research is not sponsored by educational institutions or other institutions. This research is a preliminary research which forms the basis for the development of learning tools and media that support effective, efficient and meaningful learning.

Conflicts of Interest
The research was carried out with the aim of finding out the problems faced by students in studying organic chemistry and its applications. Research findings are used to improve learning processes and media that will be used to improve learning quality and student abilities. Data analysis and interpretation was carried out objectively and with full accuracy. Research funding is done independently. Donors are not involved in planning and designing research.

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