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Challenge in Biochemistry Courses: A Snapshot of Student Learning Difficulties

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Abstract

Biochemistry with a broad and complex scope of material causes students to have difficulty in visualizing or understanding the concepts (metabolic pathways, molecular structures, and terms in biochemistry). This study aims to get an overview of students' learning difficulties in studying biochemistry. The study used a descriptive method. The research subjects were students of Biology Education at one of the universities in West Sumatra. The research instrument consists of a questionnaire of student opinions on learning difficulties and a test of mastery of concepts. It was found that 26.47% of students had difficulties in molecular structure material, 58.82% in metabolic pathway material, and 14.71% in term in biochemistry material. The students have difficulty in learning biochemistry concepts as shown by average lecture achievement score of 0.51 which is in a quite difficult range. The questionnaire results of student opinions on learning biochemistry show that 27% of students like learning using the practicum method.

Keywords: learning difficulties, metabolic pathways, molecular structure, terms in biochemistry

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1. Introduction

Biochemistry is a science that studies the chemical composition of living things, the structure of their substance, and their transformation in the body of living things, commonly known as metabolism (Butnariu et al., 2018). Biochemistry material generally includes an introduction to biochemistry, biomolecules, enzymes, metabolism, gene expression, and replication (Voet et al., 2016). Rodwell et al. (2018) discuss biochemistry material in several discussions, including 1) the structure and function of proteins and enzymes; 2) kinetics, mechanisms, regulations, and the role of enzyme metal transitions; 3) bioenergetics; 4) carbohydrate, lipid, protein, and amino acid metabolism; 5) structure, function, and replication of macromolecules; 6) biochemistry of extracellular and intracellular communication. The analysis of chemical composition in the body, the complexity of substance changes in living things, and the investigation of vital chemical processes are also discussed (Butnariu et al., 2018). Perumcheril (2017) explains that biochemistry discusses amino acids and proteins, carbohydrates, fats, molecular

genetics, heme and hemoglobin metabolism, biological oxidation, and the Krebs cycle. In a more concise discussion, biochemistry discusses amino acids and proteins, lipids, carbohydrates, and nucleic acids (Żymańczyk-Duda et al., 2016).

Some schools and colleges also include biochemistry as a course. One of the competency standards in biochemistry courses is that students have knowledge related to biochemical reactions involved in the body's metabolism and can develop their applications in everyday life with material that includes carbohydrate, protein, lipid, vitamin, mineral, and so on (Wijayanti & Lestari, 2017). Biochemistry studies can also include the chemical composition of cells, the nature of chemical reaction compounds that occur in cells, and the application of chemical principles in understanding biology (Wahyuni, 2019). Each learning resource in the form of textbooks, dictates, and articles on biochemistry has a material order that is different from each other but has the main component elements of biochemistry material; the structure and function of biomolecular and metabolic pathways. The biochemistry course at the Biology Education Study Program is a course that contains the structure and function of cells, carbohydrates, proteins, fats, nucleic acids, enzymology, biological oxidation and biochemical energy, the process of anabolism and catabolism of carbohydrates, fats, proteins. It can be said that biochemistry courses equip students to be able to understand the material structure of living things and the physiology of living things. Therefore, biochemistry is one of the interdisciplinary courses that is important to be taught to prospective students of science, biology, and chemistry.

Biochemistry lectures have been carried out on an active student basis. Face-to-face learning in class is also attended by students enthusiastically and earnestly. Learning is also assisted by practicum activities and utilizing information technology, as learning should occur in the era of the Industrial Revolution 4.0. Learning that has been pursued in such a way does not seem to be able to provide good results, as seen from student learning outcomes both through quizzes and midterm exams for students who take biochemistry courses in 2022/2023 academic year. Low learning outcomes are one indication of learning difficulties (Rizki et al., 2017). Wahyuni (2019) strengthens that students who have learning difficulties are proven by low summative exam results.

Problems that occur with students who take biochemistry courses can be classified as learning difficulties. Learning difficulties are a condition in learning characterized by certain obstacles to achieving learning outcomes (Cahyono, 2019). Learning difficulties can also be interpreted as a psychological disorder of a learner who has a perfect physique but has difficulty accepting or capturing learning well (Utami, 2019). Learning difficulties can be further studied through learning difficulty diagnosis activities. Diagnosis of learning difficulties is all efforts made to find learning difficulties, determine the types of learning difficulties experienced, the characteristics of learning difficulties, learn about the factors that cause learning difficulties and know ways to prevent and overcome learning difficulties (Ismail, 2016). Diagnosis of student learning difficulties can be overcome by conducting diagnostic tests by test or non-test, through interviews, observations, etcetera.

The diagnosis of biochemistry learning difficulties has been made by Halmo et al. (2018). The research revealed that learning difficulties in biochemistry can occur in amino acid materials and noncovalent interaction mechanisms. Widyaningrum and Wijayanti (2019) stated that students cannot carry out biochemistry practicum systematically, where students should be trained in biochemistry and practicum courses through practicum. Rahmatan (2016) analyzes aspects of biochemistry material that are difficult for students to understand. It is stated that the concept that is difficult to understand is carbohydrate metabolism, which contains abstract concepts and concepts that state processes. Therefore, to help students learn it, computer-based biochemistry learning was developed with drill and practice models

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packaged in software that can measure students' mastery of concepts and creative thinking skills. The reason many students have difficulty learning biochemistry is that the biochemistry material is dense, but lecture time is limited, and students prefer electronic media for learning the material (Munawaroh et al., 2019); the limited characteristics of material and teaching materials (Wahyuni, 2019); many concepts must be learned, concepts that are not relevant to student life, and to understand biochemistry concepts higher-order thinking skills are needed (Usman, 2019). Biochemistry is a subject that is considered difficult also expressed by Lismaya (2017), Bukhari et al. (2019), and Usman (2019). Perumcheril (2017) even reveals that biochemistry is a boring lesson.

Based on the presentation of the previous research, it is necessary to conduct an analysis of the difficulty of learning biochemistry in students of the Biology Education Study Program. This research needs to be carried out as part of an effort to evaluate the learning difficulties of student biochemistry courses. This research can also serve as material for need analysis to overcome student learning difficulties. Furthermore, this study aims to reveal student learning difficulties and to help students find solutions in the learning process and learning biochemistry courses, especially for students of the Biology Education Study Program. Various efforts to improve the learning and learning process from the results of evaluation and need analysis are expected to be carried out and realized in accordance with student characteristics, the condition of learning facilities and infrastructure in accordance with the demands of the curriculum as prospective teachers and students need biochemistry courses as an essential provision for studying further courses.

2. Research Method

This study was a descriptive study using Midterm Exam test results and questionnaires. The population in this study is students of the Biology Education Study Program at a University in West Sumatra who are taking biochemistry courses. The participants in this study were 17 students of the class of 2021/2022 who took the Biochemistry Course and were selected based on purposive sampling techniques. The study was conducted in April 2023.

Midterm Exam test data is collected and analyzed per question item, where each the question has indicators according to predetermined learning outcomes. To see the difficulties experienced by students on each of these questions, the level of difficulty experienced by students is interpreted according to Table 1.

Table 1. Range of Interpretation of Learning Difficulties (Goldberg & Erickson, 2020)

Range	Interpretation
0.00-0.29	Very difficult
0.30-0.49	Difficult
0.50-0.69	Quite Difficult
0.70-0.89	Easy
0.90-1.00	Very Easy

Data was also collected using questionnaires. The questionnaire contains open-ended questions with indicators: 1) student learning resources; 2) the way students learn; 3) the form of learning expected by students; 4) students' difficulties in learning biochemistry materials. Each indicator contains one question item. The data that have been obtained are analyzed qualitatively using percentage techniques.

3. Result and Discussion

Overall, students have difficulty learning biochemistry concepts, as shown by an average lecture achievement score of 0.51, so it is in quite a difficult range, as shown in Table 1. Of the 17 students, only four obtained scores in the quite difficult range, and 13 students were in the difficult range; for the easy, very easy and very difficult categories, there were none.

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Based on the learning difficulty test conducted on Biochemistry students, data are shown in Figure 1.

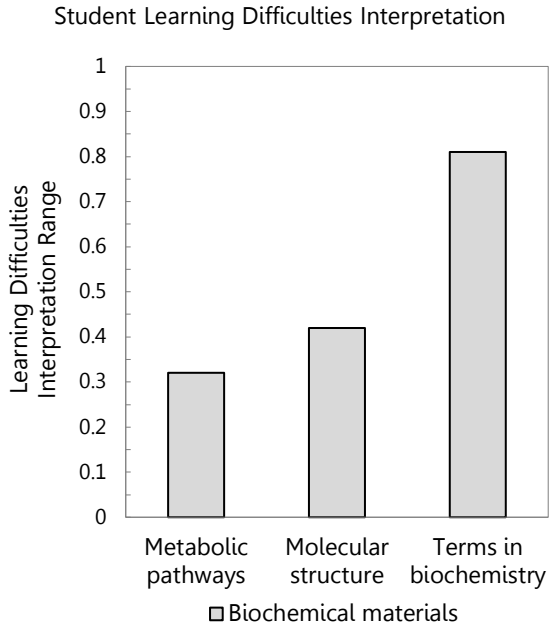

Figure 1. Interpretation of Student Learning Difficulties Based on Test Results

Based on the test results it is known that students have the most difficulty in metabolic pathway material, with the difficulty level being in the difficult category, which is 0.32. The difficulties experienced by students in studying biochemistry are caused by several things, including 1) the terms used in biochemistry are difficult for students who are new to this course to understand; 2) concepts in biochemistry are complex and often involve the use of molecular models and diagrams that require visual understanding, students have difficulty interpreting or creating molecular models; 3) biochemistry involves many structures, reactions and metabolic pathways that require rote memorization, students have difficulty in remembering all this information; 4) biochemistry is an integration of various fields of science, such as chemistry, cell biology, and genetics. It is challenging for students to comprehend, apply, and integrate these concepts.

To see how the distribution of biochemistry material difficulties faced by students is carried out, questionnaires containing questions that can be answered openly by students are distributed. The results of the questionnaire analysis are shown in Table 2.

Table 2. Results of Analysis of the Difficulty of Biochemistry Lecture Material

No	Material	Percentage (%)
1.	Metabolic Pathways	58.82
2.	Molecular Structure	26.47
3.	Terms in Biochemistry	14.71

Molecular structure, metabolic pathways, and biochemistry words are the three main areas in which students typically struggle with biochemistry materials, according to the findings from the investigation in Table 2. The highest difficulty is in the material of the metabolic pathways, which is as much as 58.82%. It is aligned with the depicted information in Figure 1. In the metabolic pathway test, students are asked to explain the function of each biomolecule in the metabolic pathway. The average student can only mention what is included in the biomolecule; students cannot analyze how each biomolecule performs its functions after being in the metabolic pathway. Thus, from the interpretation of student learning difficulties based on Table 1, students' difficulties are in the very difficult range in the metabolic pathways material.

The follow-up question given to the students is, *"Various kinds of cells in living bodies have other glucose decomposition systems besides glycolysis that occur in the cytoplasm, dehydrogenation of glucose 6-phosphate to 6-phosphogluconate is the first stage reaction. Describe the metabolic pathways that occur in the cytoplasmic fluid!"*. Four students who answered this question in the relatively difficult range did so in the following ways: *"The metabolic pathway that occurs in the cytoplasmic fluid is called the phosphogluconate junction pathway whose main task is to produce a form of energy source other than NADH (nicotinamide adenine dinucleotide), that is NADPH (nicotinamide adenine dinucleotide phosphate), another task in this metabolic pathway is the entry of pentose into glycolysis,*

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and also used in lipid biosynthesis". In addition, for the depiction of metabolic pathways, none of the students can create. Accordingly, these four students' learning difficulties on the phosphogluconate metabolic junction pathway fall into the difficult category, and 13 individuals' learning difficulties fall into the extremely difficult range since they cannot answer.

The molecular structure is also described when asking students to show how the protein denaturation process occurs and what causes the denaturation. Students have not been able to describe how protein structures are denatured, for example, when caused by the heat of the molecules released when denaturation occurs. Most students cannot define the structure of proteins when heavy metals impact them or how certain structures are released from the protein. Therefore, if the percentage of 11 people out of 17 students is in the easy category, the interpretation of student learning difficulties means that most students have begun to understand the molecular structure in biochemistry.

In the material terms in biochemistry as many as 14.71% of students experience difficulties, this means that 85.29% of students understand terms in biochemistry. Students have been able to classify the four main groups of carbohydrates and the source of each carbohydrate. A total of 14 people is already at the easy level; two students are at the very easy level. It shows that students already understand terms in biochemistry. Students already understand the concept of vitamins and minerals needed by the body, the classification of these vitamins and minerals, and from which food sources each vitamin and mineral come.

Based on the discussion above, the factors that cause students' difficulties in studying biochemistry can be described: 1) biochemistry combines concepts from biochemistry and biology, lack of basic understanding of these two concepts can make it difficult for students to understand biochemistry; 2) difficulty in understanding abstract concepts, students have difficulty in visualizing molecular structures or chemical reactions that occur at the molecular level; 3) broad and complex biochemistry topics, the amount of material that must be studied becomes overloading for students, such as metabolism covered by lipids, proteins, carbohydrates, protein synthesis, molecular genetics; 4) lack of adequate laboratory practice can make it difficult to understand practical concepts in biochemistry; 5) lack of effective study skills is also a factor causing difficulties in learning biochemistry, effective study is also related to the motivation of these students in studying biochemistry, effective study can be raised by making good material notes, streamlining study time, seeking additional support and assistance, both from lecturers, classmates and other resources. It is shown in Table 3 regarding how to learn biochemistry students, obtained based on the results of an open questionnaire.

Table 3. Results of Analysis of How to Learn Biochemistry Materials

No.	How to Study	Persentase (%)
1.	Discussion	19.70
2.	Lecturer's Explanation	21.21
3.	Learn about videos	12.12
4.	Studying Images	9.09
5.	Using the app/software	4.55
6.	Practicum	27.27
7.	Assignment	6.06

Previous research on learning difficulties has been conducted by Sahade and Rijal (2018) and Nofitasari and Sihombing (2017), which state that internal and external factors can influence learning difficulties, which is generally applicable. Internal factors include student conditions, interests, learning motivation, and how students learn; for example, they prefer learning using electronic media (Munawaroh et al., 2019). This internal factor will affect the ability of students to understand the material presented by lecturers, not record the material studied, and not do assignments on time (Sahade &; Rijal, 2018). External factors that influence are the characteristics of the biochemistry material itself, the availability of teaching materials and teaching methods (Utami, 2019). The limitations of the methods used in learning

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can also affect the difficulties in learning biochemistry (Susilo, 2017). For this reason, this study also analyzed how students prefer learning biochemistry, as shown in Table 3.

Based on the results of the data in Table 3, students like lectures with practicum methods; this indicates that students prefer to learn by being actively involved and doing direct learning. It is hoped that with the high preference of students through this way of learning with practicum, lecturers can develop practicum instructions and practicum assessment instruments (Puspitasari, 2018) more comprehensively and accommodate student needs to overcome learning difficulties. Based on the results in Table 3, lecturer explanations and discussions with lecturers and colleagues are still the top priority of how students want to learn. It reflects that learning resources such as books, applications/software, videos, images, and other media have not been utilized optimally to build student knowledge.

Under current technological developments, using visual media such as videos and applications should be the right choice to increase students' knowledge and understanding of learning. Studying videos is still an option that many students choose to use in learning (Seruni et al., 2019). Therefore, lecturers can develop e-modules in learning that can be integrated with videos. According to Uliyandari et al.'s (2019) research, instructional materials were created to help students overcome learning challenges by using modules that enhanced learning outcomes and student responses in the subject of biochemistry.

Learning difficulties in students related to biochemistry materials, as shown in Table 2, is a phenomenon that occurs in various higher education institutions, as revealed by Bukhari et al. (2019), Munawaroh et al. (2019), Usman (2019), Widyaningrum and Wijayanti (2019), Halmo et al. (2018), Lismaya (2017), and Rahmatan (2016). The students learning difficulties in the Biology Education Study Program at one of the universities in West Sumatra include molecular structure, metabolic pathways, and terms in biochemistry. These three material categories are generally because biochemistry has a broad scope of knowledge but usually takes a short time to study (Munawaroh et al., 2019).

The molecule's structure is usually presented in the form of a diagram. Similarly, metabolic pathways are usually presented in the form of flow charts. McLure et al. (2022) state that diagrams can be used to provide complex scientific explanations. However, using diagrams in science learning can be difficult for students because diagrams are usually interpreted at the surface level without further understanding the meaning of the diagrams presented in biochemistry learning resources. Skills in interpreting diagrams depend on students' prior knowledge of both scientific and diagrammatic concepts (Liu et al., 2014). Furthermore, errors in reading and interpreting molecular structure diagrams that are the basis of biochemistry can lead to misconceptions about biochemistry materials and an inability to understand more complicated and complex biochemistry materials, such as molecular group change reactions and metabolism.

It is also challenging to understand metabolic pathways and be less able to read diagrams because it requires students to combine many ideas from various scientific disciplines (Salame et al., 2022). The presentation of metabolic pathway material in learning resources is generally in the form of a flow chart accompanied by molecular structure, chemical formula, molecular name, arrows describing the reaction's direction, and enzymes that catalyze each change. Detailed material on metabolic pathways raises problems, which must be understood or memorized with each step. It increases the problem of student learning difficulties in understanding biochemistry materials.

In biochemistry materials, there are many terms used. As the structure changes, so does the term used and the notation. For example, the term that is often used is glucose. In its discussion in biochemistry learning, glucose is not just sugar; it is a simple sugar belonging

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to the monosaccharide group. Glucose has the chemical formula $C_6H_{12}O_6$. Another difficulty in understanding terms in biochemistry materials is that other terms must be understood and known. For example, to understand a term in biochemistry such as galactosemia, students must be able to know about sugars, glycoside bonds, amino acids, proteins, enzymes, and the hierarchical structure of metabolic pathways that concern the term. Difficulties in recognizing and understanding terms can make it more difficult for students to study biochemistry materials.

Based on the analysis results, lecturers' explanations and discussions with lecturers and colleagues are still the main choices of students. This reflects that existing learning resources, such as books, videos, images, and other media, are still unable to be utilized optimally by students in building knowledge.

The diagnosis of student learning difficulties has implications for efforts to minimize and overcome student learning difficulties in biochemistry learning. Future efforts that can be made based on the data in Table 3 are to carry out various developments related to learning media such as videos, learning impressions equipped with images and animations to make students more focused and directed in understanding the material, improve the learning process; and also develop teaching materials that are easy to understand the language and have a sequence of material that is tailored to the needs of students in learning the material biochemistry.

Furthermore, based on the results of the analysis carried out, it is also necessary to develop biochemistry teaching materials that are: 1) the content is tailored to the needs of prospective teachers, containing material in accordance with the Core Competencies and Basic Competencies of Science in Junior High School and Biology in Senior High School; 2) the language is simple so that it is easily understood by learners in this case students; 3) the presentation is coherent, so that it can help students to organize their thinking flow in studying biochemistry. The teaching materials should also contain the relationship between biochemistry materials and everyday life so that student knowledge can relate directly to reality. As a result, the teaching materials developed will motivate students to learn purposefully and gain a solid understanding of biochemistry concepts for use in lectures. It can also be used in later school instruction.

4. Conclusion

Based on the presentation of the results and discussion, it can be concluded that student learning difficulties are related to biochemistry material about molecular structure, metabolic pathways, and terms in biochemistry. Generally, students prefer to learn biochemistry through discussion activities and explanations from lecturers. Learning resources used by students in studying biochemistry material are data from the Internet, explanations from lecturers, and biochemistry books.

More research may be conducted to develop various teaching materials to help students study biochemistry. These materials can include learning videos, easy-to-understand textbooks, modules, practicum instructions, and interesting and easy-to-understand broadcast materials.

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