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# Deep Learning Ability of Students from Superior and Non-Superior Classes at Microscopic Level of Protein

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**Abstract.** Deep learning is urgently required to achieve scientific literacy and to develop high order thinking skills. This study aimed to describe the deep learning ability of science education major students in a university in East Java at the microscopic level of protein. Twenty students from superior class and thirty students from non-superior class were involved voluntarily in the survey study. By using content analysis that is read carefully students' tasks, examined students' ability in identify, define, and explain biochemical aspects of protein case, and apply the knowledge to explain the case, and determined students' learning status using rubrics, we found that students from both classes successful identified, defined, and explained aspects of protein cases macroscopically. However, microscopically, no students from the superior class explained protein aspects in the cases, while 11% of students from non-superior class explained them successfully. Seven percent of student from non-superior class used their protein knowledge to explain the protein cases they explored successfully. We also found that 7% of students from the non-superior class performed deep learning at microscopic level of protein, while no students from the superior class performed the same. However, majority students from both classes performed surface learning at microscopic level of protein. The results imply that both superior and non-superior students are difficult to learn protein microscopically. Learning strategy to help students attain meaningful learning of biochemistry are needed by the students.

## 1. Introduction

The development of science and technology in the 21st century or industrial era 4.0 will increasingly color almost all aspects of human life. All life activities become easier because of the availability of tools, facilities, and facilities supported by modern technology that helps humans in meeting their needs. But behind these conveniences, the ability needed to move in that era will also be more complex. Tools, facilities, and methods used in a variety of human activities and even the problems that they cause are increasingly complex.

Several studies (such as: [1-4]) state that to live in the 21st century and industry 4.0 era requires high order thinking skills, such as: critical thinking, problem solving and creative thinking. To attain the high order thinking skills, students' learning abilities should no longer be at a low cognitive level, such as merely understanding concepts, but must be able to apply them in life, both to explain scientific issues and overcome problems encountered in daily life [5][6]. Higher-order thinking skills and scientific literacy cannot be achieved if students still have difficulty understanding material and even experience misconceptions [7][8]. Science learning in the 4.0 era also experienced a shift from content-based



learning that is monodisciplinary to context-based learning that is interdisciplinary, such as: STEM (Science, technology, Engineering, and Mathematic).

Higher-order thinking skills and scientific literacy can only be realized if student learning is meaningfully or deep learning. Meaningful learning requires the ability to assimilate new knowledge learned with knowledge already possessed in the cognitive structure [9]. Therefore, the ability of students to construct knowledge is very important in learning meaningfully. Meaningful learning is a prerequisite for achieving deep learning, namely the ability to learn students that not only occur on the surface (surface learning) which includes understanding or definition but must reach the conceptual and multidimensional level [7][10]. Meaningful learning is the foundation of deep learning that is a requirement for achieving high-level thinking skills [11] and Science literacy [6].

Deep learning will be successfully performed in classroom if there is a connection, coherence, and integration of aspects of context. There are three indicators of deep learning, namely the ability to master of existing knowledge, constructing new knowledge, and using knowledge in everyday life [11]. These indicators can be identified by assessing students' ability to identify, define, and explain aspects learned in the context and use the knowledge to explain the context including solving problems [6].

At the level of deep learning, student knowledge becomes increasingly dynamic or always develops due to the construction of knowledge. Biochemical deep learning is not possible if students are still rote learning [12] or only surface learning occurs at the macroscopic level [6] [12], but learning must occur at the microscopic level [11]. Biochemistry, including protein, is knowledge at the microscopic and even submicroscopic level which studies chemical processes in cells that are abstract, symbols, and involve macromolecules and complex biochemical processes [6, 18]. Understanding biochemistry requires deep learning skills

### *1.1. Overview Macroscopic and Microscopic Knowledge of Biochemistry*

Biochemical material is basically microscopic, abstract, and complex [6][13]. Metabolic processes, such as carbohydrate, fat, and protein metabolism are abstract, theoretical, and cannot be responded to by the senses. To study material with these characteristics requires the ability to think abstractly [14]. Nevertheless, in various scientific issues, many cases related to biochemistry are presented macroscopically to be easily understood by the general public [6]. At the macroscopic level, many metabolic disorders are only presented in general terms, such as: a child has poor nutrition or lacks protein intake. Another example is excess cholesterol is often thought to occur because many consume foods that contain high cholesterol without examining in detail how the metabolism of cholesterol in cells. Understanding the material macroscopically can be done through surface learning

### *1.2. Rote Learning and Meaningful Learning*

Before rote learning, there is one more category called no learning that occurs when a person can only reveal a small part about a particular object or concept. But if someone has been able to uncover a certain object or concept with more or a majority of the object or concept it can be categorized as rote learning, even though it only reaches the level of definition or macroscopically [6]. Both no learning and rote learning, knowledge construction does not occur in the structure of cognitive and difficult to use to explain scientific issues and overcome problems in everyday life [15][12].

### *1.3. Surface Learning and Deep Learning*

Surface learning generally starts from rote learning. Many aspects can be disclosed but only limited to the understanding, definition, and relationship between the terms macroscopically [6, 11]. At this level, general knowledge can only be memorized, described or even exemplified but not understood in its meaning or only on the surface [16]. Students at this level of learning can solve problems that may be categorized as mathematically complicated, but that happens because the procedure is memorized due

to the exercises they do. But when there are one or more variables manipulated, the student cannot solve the problem because the procedure has changed [17].

Deep learning occurs when it is meaningful learning. Students already understand in detail about objects or concepts, both macroscopically and microscopically categorized as achieving deep learning [11]. At this level of learning, students not only memorize the problem-solving procedure but also conceptually master what is known and want to be known in the problem. Even when the variables are exchanged, added, or even subtracted, he knows the implications.

## 2. Method

Using a survey design, we describe the students' deep learning potential on the macroscopic and microscopic aspects of biochemical material through 3 stages. First, the exploration stage, namely describing the biochemical cases explored by students on the topic of protein, 2) the stage of explaining biochemical aspects macroscopically and microscopically, and 3) applying biochemistry to explain cases and presentations. Twenty students from superior class students and 30 students from non-superior classes in an undergraduate program of Science who enrolled in biochemistry classes from a University in Indonesia in 2019, voluntarily participated in this study.

To collect data, we use five assessment rubrics that have been validated by 2 biochemistry lecturers and 1 science education lecturer, namely: 1) rubric of ability to explore cases, 2) rubric of ability to identify biochemical aspects in cases, 3) rubric of ability to define biochemical aspects, 4) the ability to describe biochemical aspects, and 5) the rubric of the ability to explain biochemical aspects, and 6) the rubric of the ability to explain cases using the biochemical aspects that they have learned. In addition, interviews with 5 excellent students and 5 non-excellent students were conducted to clarify the data obtained from the rubric.

Data analysis was performed descriptively using content analysis to categorize the types of student learning. In content analysis, we analyze student tasks in exploring protein cases, identifying, defining, and explaining biochemical aspects using rubrics to determine their learning status, namely: no learning, rote learning, surface learning, and deep learning [6],[11][12]. No learning if students are not able to identify biochemical aspects or only identify less than half of the biochemical aspects in the case of proteins but not defined. However, if students are able to identify and define more than half of the protein aspects but cannot explain these biochemical aspects, it is categorized as rote learning. However, if students are able to explain protein aspects but only occur at the macroscopic level, they are categorized as surface learning. At this level, students have difficulty using their knowledge to explain protein cases. Finally, students who are able to explain protein aspects at the microscopic level and explain the protein cases they are exploring are categorized as reaching the deep learning level.

## 3. Results and Discussion

The results consist of two tables, that are the biochemical cases of protein (Table 1) and students' learning categories of biochemistry (Table 2) and a figure of students' ability to identify, define, explain, and apply (idea) of biochemical aspects both at macroscopic and microscopic levels of protein. Each of tables and figure are followed by an interpretation. The discussion of the results is displayed in a separate section.

### 3.1. Result

**Table 1.** Biochemical cases of protein

Superior class		Non-superior class	
Protein cases	N	Protein cases	N
Malnutrition	2	Pirai	5
Albuminuria	1	Uric acid syndrome	13
Hypoalbuminuria	2	Defisiensi of protein	2

Superior class		Non-superior class	
Protein cases	N	Protein cases	N
Kwarshiorkor	5	Hypoproteinemia	3
Cachexia	1	Kwarshiorkor	4
Protein allergy	1	Hiperlipoproteinemia	1
Marasmus	2	Marasmus	1
Hypoalbuminemia	1	Kreatinuria	1
Hair loss	2		
Uric acid syndrome	2		
Edema	1		

Table 1 shows that the superior class students although dominated by kwashiorkor cases, the cases of protein explored by students were more varied than those of protein explored by non-superior students who were generally dominated by gout cases. This shows that the ability of superior class students in exploring protein cases or issues is higher than non-superior classes.

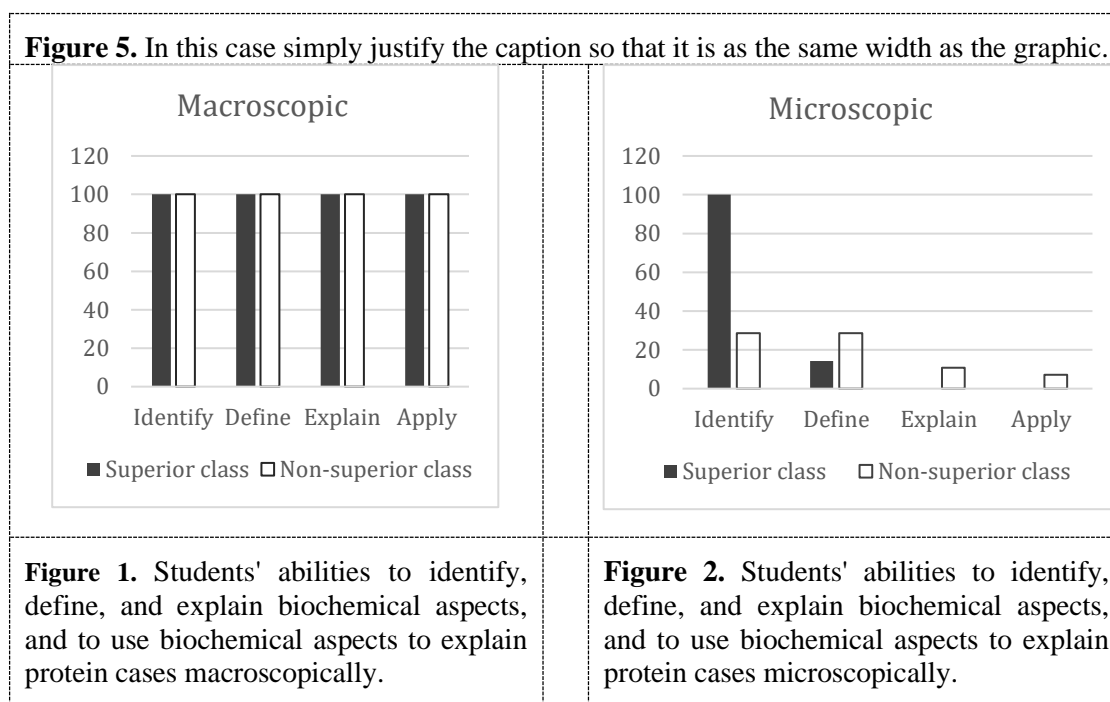


Figure 1 dan Figure 2 shows that macroscopically the students in the superior and non-superior classes are relatively the same, namely being able to explain identifying, defining, explaining, and applying biochemical aspects. But this can happen because the cases explored by students in general have been equipped with explanations in almost all aspects macroscopically. In the apply aspect, the students' explanation was the same as what was written in the explored news text.

Microscopically, the students of both classes are almost the same, although it seems that the non-superior class is relatively superior to the superior class. The superior class in general can identify biochemical aspects in a microscopic manner even though it is not perfect, but it has not yet defined and explained these aspects. Conversely, in non-superior classes, less than 50% have identified and defined

microscopic and imperfect aspects. The non-superior class a small portion (10%) has tried to apply biochemistry to explain in the issues being explored also involves microscopic aspects. This application occurs because in the issue/case it involves aspects to the microscopic level.

**Table 2.** The category of students' learning of biochemistry of protein

Learning category	Superior class (%)	Non-superior class (%)
No learning	0	0
Rote learning	0	0
Surface learning	100	100
Deep learning	0	0

The results of interviews conducted to all students based on issues/cases analyzed by students can be said that all claimed difficulty understanding the microscopic terms contained in the case. Although they can understand and even explain macroscopically, but in general, because these explanations are available in case news. Therefore, in Table 2 it appears that the possibility of new students learning on the surface or at the macroscopic level, but not yet at the microscopic level. Students also in both classes cannot memorize biochemical terms in the case they are analyzing.

### 3.2. Discussion

The data in Table 1 shows that science issues, especially health cases that are related to protein in everyday life, are easily found by students. However, these protein cases are easy for students to explain at the macroscopic level, but difficult at the microscopic level (Figure 1). Consequently, students from both superior and non-superior classes were only performed surface learning (Table 2). At the macroscopic level, an explanation of protein cases is actually available in every case report on the internet or other social media. The language used also uses the language of media for communication with the public in general [6]. Molecular symbols are not used at the macroscopic level [18].

Knowledge learned at the macroscopic level is only factual, informative and does not display conceptual knowledge. To learn knowledge at the macroscopic level it is sufficiently to just performed the surface learning [11], even with rote learning [12]. Students can provide as much information as possible, but only at the surface level. The construct of knowledge may occur at this level, but it is difficult to use to explain related issues in detail because of the limited knowledge [5, 19].

Learning at the macroscopic level is generally mostly done by students who are only able to operate their concrete thinking skills (Piaget, 1964). The level of scientific literacy that can be achieved by students who performed the surface learning is generally at the level of functional literacy [7, 10]. At this level, it is difficult for students to be able to ask questions critically [2], critical thinking [3], high-level thinking and problem solving [1, 21] and metacognitive [22].

The results of research [5] found that teachers had difficulty explaining scientific issues, such as protein issues occurred, because of difficulties in identifying, defining, and explaining the biochemical aspects involved in the issue. The results of research [6] also found that the difficulty of students explaining science issues even though the issue was closely related to their interest besides the low ability to use abstract thinking skills as well as the lack of basic knowledge as a foundation for knowledge to explain aspects biochemistry in each case analyzed. The results of this study do not support to what was discovered by [23] and [24] who found that context-based biochemical learning that was of interest could increase students' biochemistry motivation and learning outcomes [25].

At the microscopic level, atomic and macromolecular symbols, biochemical reaction equations, and conceptual knowledge that are displayed meaningfully are very dominant [18, 26]. At this level, abstract thinking ability is needed to understand abstract concepts and symbols as well as functional relationships between abstract concepts conceptually [6, 5]. If students are able to learn at the microscopic level, the opportunity to achieve meaningful learning and deep learning is very large ([17],

[11, 16]. At this level, learning will trigger students to achieve critical thinking skills and high-level thinking [22] [2] and will potentially achieve the multidimensional level of scientific literacy [7, 10, 6].

The implication of the results of this study is that in order to achieve deep learning and meaningful learning in the field of biochemistry, students must start practicing from the beginning, especially when learning basic knowledge even if only macroscopically. Meaningful learning habits continue to be built accompanied by an increase in students' abstract thinking capacity [20, 27]. In addition, the grouping of students into superior and non-superior classes should pay attention to their learning abilities and thinking capacity in addition to consideration of English language skills.

#### 4. Conclusion

The ability of superior and non-excellent class students in achieving deep learning in biochemical learning is relatively the same, namely macroscopically good but microscopically still difficult. Both new groups can learn at the surface level (surface learning) and have not yet reached deep learning. In addition, both groups of students also had difficulty memorizing biochemical terms (protein). In explaining facts, concepts, principles, law, and theory, the superior class has better ability to define but in the aspect of explaining, the two groups are relatively difficult, even the non-superior class is slightly better than the superior class. Thus, the two classes are relatively different in level of learning. The main cause in the difficulty of achieving deep learning is the difficulty in defining biochemical terms and transforming them to explain biochemical material. Many biochemical terms are quite complex and abstract.

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