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Investigation of Learning Outcomes in Biology Course Curriculum in Terms of Mental Skills

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Abstract The purpose of this study is to examine the learning outcomes in the curriculum of Biology course in terms of reflective thinking skills. It is a documentary qualitative research. The target area of the study is the curriculum of the Biology course in secondary school level. Biology course curriculum of grades 9-12 was included in the research without any sampling in the research. Data collection method of the research is document analysis, and data analysis method is content and document analysis. We find that the vast majority of the learning outcomes of the units and subject areas in the biology course curriculum are in the practical reflection level. While the learning outcomes of the biology course curriculum are determined, mental skills need to be taken into account.

Keywords Biology Course, Curriculum, Reflective Thinking Skills

1. Introduction

Technological developments in the production, use, and transfer of scientific knowledge have led to many innovations in Biology science. Especially with new developments in genetic engineering and biotechnology, biology has become a part of our daily life and this has increased the requirements for biology education [1]. In the Biology Course Curriculum, the contribution of Turkish-Islamic scientists to science, in particular, to the role of biology in human life and science history, has been included. The development of knowledge, skills, competencies, and values of students in relation to the interactions between science, technology, society, and environment has been emphasized [2]. In this context, the Biology Course Curriculum is redesigned in a way to make innovations and changes in the light of laws, theories, practices, and concepts of biology to provide more room for applications such as research and questioning, using information technology, establishing a relationship between biology and daily life, and creating social awareness [3]. High-level thinking skills of the students need to be developed so that the achievements in the updated curriculum can be reached. Different researchers classify thinking skills in different ways. Üstünoğlu [4] distinguishes high-level thinking skills as critical thinking, creative thinking, analytical thinking, reflective thinking, and problem-solving.

Among these skills, reflective thinking enables students to realize weaknesses and strengths [of their actions] by giving them an in-depth thinking of remove brackets actions they performed are planning to perform, to figure how they will make up deficiencies in their actions, as well as to understand their own and others' learning and thinking processes by observing their efforts of making sense [5]. To develop reflective thinking skills, it is first necessary to understand the different levels of this thinking skill. Although different models have been developed to determine reflective thinking levels, the most important model for the classification of reflective thinking skills has been developed by Max Van Manen [6]. The most important feature of this model is that it reveals the reflection levels very clearly [7]. Van Manen has introduced three levels of reflection: technical, practical, and critical. In the technical reflection, teachers or prospective teachers try to achieve the goals of the curriculum without questioning the educational values of the goals of the curriculum they are practicing. It focuses only on educational knowledge and on the principles necessary to achieve the identified goals [6]. In the practical reflection, teachers or prospective teachers analyze student behaviors to understand whether they reached the goals, if reached how they are reached, if not why they have not been reached. They interpret the observable student behavior based on individual perceptions [8]. The critical reflection takes into account social conditions to address value. Taking social conditions into account requires that ethical values are also considered. [9, 10, 11].

It is not just that individuals can effectively learn reflective thinking and effectively utilize these skills. In this regard, educational institutions play an important role in developing reflective thinking skills [12, 13]. For this reason, it is aimed to educate the students who are thinking,

criticizing, producing, knowing how to reach the information, knowing how to identify the problems they encounter and develop solutions for these problems, and thus, curriculums to give the students the skills of thinking are prepared in modern schools [14, 15]. From this point, the units, subject areas, and learning outcomes in the curriculum should be determined to improve the reflective thinking skills of the students. The aim of this study is to examine and discuss the learning outcomes of the biology course curriculum in terms of reflective thinking skills.

2. Method

This study, which aims to examine the achievements in biology curriculum in terms of reflective thinking skills, is a documentary research which is a qualitative method in terms of data sources and data analysis. Written and visual materials related to the research problem can be used for research if there is no possibility of direct observation and interviewing in the analysis based on the document analysis. With this method; the general trends, the subjects that are studied or not studied in the subject area, and the existence of alternative ideas become clearer [16]. According to Çepni [16], document analysis is the process of collecting the current records and documents related to the study to be performed and encoding and reviewing it according to a certain norm or system. Document analysis is also described as documentary observation or documentary screening ".

2.1. Data Collection and Analysis

The data in the survey were obtained by document examination [17, 18]. Secondary data were used in the research conducted. "Secondary data are information that other researchers have collected, unlike individuals who do the research"[16]. In the analysis of the research data, document analysis and content analysis were used. The content analysis consists of defining the goals, defining the concepts, determining the units of analysis, locating the data related to the subject, developing a logical structure, determining the coding categories, counting, interpreting, and writing the results [17]. The results obtained from the analysis were evaluated with descriptive statistics such as frequency and graph. Coding reliability technique has been applied to determine the reliability of content analysis. The concordance between the coders is calculated with the reliability coefficient with the formula [19]. After the coding reliability calculation, the agreement rate between the coders in the study was 85%.

3. Findings

In this study, which aims to examine the learning outcomes in biology course curriculum in terms of reflective thinking skills, a description has been made by tabulating the learning outcomes separately and unit by unit with indicating the skill they are related with below.

Table 1. Evaluation of learning outcomes in the ninth-grade biology course curriculum in terms of Reflective Thinking Skills

Unit	Subject	Learning Outcomes	Reflection Level
Cell	Cell	Explains the studies on cell theory	Practical Reflection
		Explains cellular structures and their tasks	Practical Reflection
		A controlled experiment on cell membrane permeability	Practical Reflection
Living World	Diversity and Classification of Creatures	Explains the importance of classification in understanding the diversity of living things	Practical Reflection
		Explain the categories used in the classification of living things and the hierarchy between them with examples	Practical Reflection
	Living Worlds and Their Features	Explains the worlds used in the classification of living things and the general characteristics of these worlds.	Practical Reflection
		Explains the contribution of living things to biological processes, economics, and technology with examples	Practical Reflection
		Explains the general properties of viruses	Practical Reflection
Life Science Biology	Common Features of Biology and Living Things	Examines common features of living things	Practical Reflection
	Basic Compounds in the Structure of Living Things	Explains the organic and inorganic compounds that make up the structure of living things	Practical Reflection
		Establishes the relationship of lipids, carbohydrates, proteins, vitamins, water, and minerals to healthy nutrition	Practical Reflection

All learning outcomes in the grade 9 biology course curriculum fall into the practical reflection area (Table 1). Practical reflection can be defined as a reflection area where teachers or prospective teachers begin to take advantage of their experience in teaching skills, to think about the problems they face and to find solutions. In this area teachers or prospective teachers analyzes student behaviors to understand whether the goals are reached, if reached how they were reached, if not why. Similar findings were also found in studies conducted by Bataineh, Karasnah, Barakat, and Bataineh [20].

Table 2. Evaluation of learning outcomes in the tenth-grade biology course curriculum in terms of Reflective Thinking Skills

Unit	Subject	Learning Outcomes	Reflection Level
Cell Divisions	Mitosis and Asexual Reproduction	Explains the necessity of cell division in living things	Practical Reflection
		Explains mitosis	Practical Reflection
		Explains the asexual reproduction with examples	Practical Reflection
	Meiosis and Sexual Reproduction	Explains meiosis	Practical Reflection
		Explains sexual reproduction with examples	Practical Reflection
General Principles of Inheritance	Inheritance and Biodiversity	Explains the general principles of inheritance	Practical Reflection
		Question the role of genetic variation in explaining biological diversity	Practical Reflection
Ecosystem Ecology and Current Environmental Problems	Ecosystem Ecology	Explains the relationship between living and nonliving components of the ecosystem.	Practical Reflection
		Explain the forms of nutrition of living things with examples	Practical Reflection
		Analyzes the flow of substance and energy in the ecosystem	Practical Reflection
		Establishes a relationship between substance cycle and the sustainability of life	Practical Reflection
	Current Environmental Problems and Human	Evaluate the causes and possible consequences of current environmental problems	Critical Reflection
		Questions about the role of the individual in the emergence of environmental problems	Critical Reflection
		Suggests solutions for environmental pollution prevention in the local and global context	Critical Reflection
	Conservation of Natural Resources and Biodiversity	Explain the importance of the sustainability of natural resources	Practical Reflection
		Question the importance of biological diversity for life	Critical Reflection
		Suggests solutions to protect biodiversity	Critical Reflection

There are a total of 17 different learning outcomes of different units in the curriculum. Many of the outcomes (n = 11, f = 65) belong to the practical reflection. When the learning outcomes belonging to the practical reflections are examined, it is seen that the outcomes are designed to put forward explanation and interpretation skills instead of a descriptive sufficiency. Similarly, Hatton and Smith [10] found that prospective teachers have focused on the technical aspects of teaching at the beginning of the developmental process of reflective thinking. Moreover, the critical reflection was also determined in the curriculum (n = 6, f = 35). When we look at the learning outcomes in the critical reflection, it seems that there are outcomes for inquiry, development of new suggestions, and making different evaluations. The learning outcomes that have student-centered learning approaches encourage students to question and actively participate in the classroom [21].

Table 3. Evaluation of learning outcomes in the eleventh-grade biology course curriculum in terms of Reflective Thinking Skills

Unit	Subject	Learning Outcomes	Reflection Level
Human Physiology	Supervisor and Regulatory System, Sense Organs	Explains the structure, duty, and functioning of the nervous system	Practical Reflection
		Explains endocrine glands and the hormones they secrete	Practical Reflection
		Gives examples of nervous system disorders	Practical Reflection
		Makes inferences relevant to what needs to be done to protect the healthy structure of the nervous system	Critical Reflection
		Explains the structure, duty, and functioning of sensory organs	Practical Reflection
		Explains the disorders of sense organs	Practical Reflection
		Makes inferences relevant to what needs to be done to protect the healthy structure of sense organs	Critical Reflection
	Support and Motion System	Explains the structure, duty, and functioning of support and motion system	Practical Reflection
		Explains the disorders of support and motion system	Practical Reflection
		Makes inferences relevant to what needs to be done to protect the healthy structure of support and motion system	Critical Reflection
	Digestive System	Explains the structure, duty, and functioning of the digestive system	Practical Reflection
		Explains the disorders of the digestive system	Practical Reflection
		Makes inferences relevant to what needs to be done to protect the healthy structure of the digestive system	Critical Reflection
	Circulation System	Explains the structure, duty, and functioning of the circulation system	Practical Reflection
		Explains the circulation of the lymph	Practical Reflection
		Explains the disorders of the circulation system	Practical Reflection
		Makes inferences relevant to what needs to be done to protect the healthy structure of the circulation system	Critical Reflection
		Explains immune varieties and natural defense mechanisms of the body	Practical Reflection
	Respiratory System	Explains the transport of gas from alveoli to tissues and alveoli from tissues	Practical Reflection
		Explains the structure, duty, and functioning of the respiratory system	Practical Reflection
		Exemplifies respiratory system diseases	Practical Reflection
		Makes inferences relevant to what needs to be done to protect the healthy structure of the respiratory system	Critical Reflection
	Urinary System	Explains the structure, duty, and functioning of the urinary system	Practical Reflection
		Indicates the role of the kidneys in providing homeostasis	Practical Reflection
		Exemplifies urinary system disorders	Practical Reflection
		Makes inferences relevant to what needs to be done to protect the healthy structure of the urinary system	Critical Reflection
	Reproductive System and Embryonic Development	Explains the structure, duty, and functioning of the reproductive system	Practical Reflection
		Makes inferences relevant to what needs to be done to protect the healthy structure of reproductive system	Critical Reflection
		Explains the embryonic development process in human	Practical Reflection
Community and Population Ecology	Community Ecology	Explains the factors that influence the structure of the community	Practical Reflection
		Explains the inter and intra-species competition in the communities with examples	Practical Reflection
		Explains symbiotic relationships among species in the community with examples.	Practical Reflection
		Explains the succession in the communities with examples	Practical Reflection
	Population Ecology	Analyzes the factors affecting population dynamics	Practical Reflection

There are 34 different learning outcomes belonging to different units in the curriculum. Significant number of outcomes (n = 27, f = 79) are in the practical reflection area. Learning outcomes for practical reflections are defined as behaviors involving explanations and comments of students on the subject. These outcomes are determined to put the student's comments forward rather than expressing their behaviors simply and plainly. Learning outcomes that are appropriate for critical reflection have been identified in this curriculum (n = 7, f = 21), although they are less than the practical reflection. When the outcomes in the critical reflection area are examined, it has been determined that the

behaviors of the students that are intended to make inferences about the subject is more focused rather than the behaviors in a simple and plain degree. In putting the distinctive deductions into outcomes, it may be aimed to use the teaching methods and materials that center the student [22].

Table 4. Evaluation of learning outcomes in the twelfth-grade biology course curriculum in terms of Reflective Thinking Skills

Unit	Subject	Learning Outcomes	Reflection Level
From Gene to Protein	Discovery of Nucleic Acids and Their Importance	Evaluates the discovery process of nucleic acids	Critical Reflection
		Describes the types and functions of nucleic acids	Practical Reflection
		Establishes meronymy in the organization of genetic material on the cell	Practical Reflection
		Explains DNA replication	Practical Reflection
	Genetic Code and Protein Synthesis	Explains the mechanism of protein synthesis	Practical Reflection
		Explains the concepts of genetic engineering and biotechnology	Practical Reflection
		Explains genetic engineering and biotechnology applications	Practical Reflection
		Evaluates the effect of genetic engineering and biotechnology applications to human life	Critical Reflection
Energy Conversions in Living Things	Living and Energy	Explain the necessity of energy for the continuation of life	Practical Reflection
	Photosynthesis	Questions the importance of photosynthesis in terms of living things	Critical Reflection
		Explains the process of photosynthesis on a diagram	Practical Reflection
		Evaluates the factors affecting the rate of photosynthesis	Critical Reflection
	Chemosynthesis	Explains the phenomenon of chemosynthesis	Practical Reflection
	Cellular Respiration	Explains cellular respiration	Practical Reflection
		Conducts experiments on aerobic respirations reactants and final products that are released by the end of the reaction.	Practical Reflection
		Makes inferences about photosynthesis and respiration relation	Critical Reflection
Plant Biology	Structure of Plants	Describes the structure and functions of the essential parts of a flowering plant	Practical Reflection
		Explains the effects of hormones in plant development with examples	Practical Reflection
		Performs a controlled experiment to observe plant movements	Practical Reflection
	Movement of the Substances in Plants	Reveals water and mineral absorption in the roots	Practical Reflection
		Explains water and mineral transport mechanism in plants	Practical Reflection
		Explains the mechanism of transport of photosynthesis products in plants	Practical Reflection
		Designs experiments related to water and substance transport in plants	Practical Reflection
	Plant Sexual Reproduction	Explains the parts of the flower and the tasks of these parts	Practical Reflection
		Explains fertilizing, seeds, and fruit formation in flowering plants	Practical Reflection
		Designs experiments that can observe seed germination	Practical Reflection
		Establishes a relationship between dormancy and germination	Practical Reflection
Living Things and Environment	Living Things and Environment	Explains the effect of environmental conditions on the continuity of genetic changes	Practical Reflection
		Gives examples of artificial selection practices in agriculture and animal husbandry	Practical Reflection

There are 29 different learning outcomes belonging to different units in the curriculum. A significant number of outcomes (n=24, f=83) are in the practical reflection area. Learning outcomes for practical reflections are defined as behaviors involving explanations and comments of students on the subject. Akay [23] states that Dewey's education approach is based on action and that students learn with practical activities related to life. The critical reflection level is lower than that of the practical reflection (n = 5, f = 17). When we look at learning outcomes in the critical reflection area, it is seen that behaviors expected from the students are rather outcomes based on inferences and evaluations. In this context, it is mentioned in the top level of reflective thinking that Van Manen [6] calls critical reflection; he questions the moral, economic, social, and systemic influence of teaching practices [24].

4. Results and Suggestions

In the examination of a total of 91 learning outcomes in the biology course curriculum, the maximum learning

outcomes are at 11th grade, while the fewest outcomes are in the 9th grade. The number of outcomes is increasing in direct proportion to the level of education. Meanwhile, the maximum number of units and subject area is set at 12th grade. The result is that most of the outcomes are at the practical reflection area. One of the remarkable results is that none of the outcomes are at the technical reflection area. Whilst a large majority of the outcomes in the practical reflection are directed at making "explanations" about the subject, almost all of the outcomes in the critical reflection focus on "inferring and evaluating". At the ninth-grade level, there is no outcome corresponding to the critical reflection level. In the remaining grades, a similar number of critical reflection outcomes have been achieved.

In addition to the applications for the development of reflective thinking skills in students, the learning outcome of subjects in the curriculum should also be determined in such a way to enable students to develop their reflective thinking skills.

Pedagogical levels of students should be taken into consideration when organizing subjects in the curriculum. Furthermore, attention should be paid to the developmental state of mental skills in the sequencing of achievements. It is necessary for developing effective interpretations for students to have experiences on subject organizing and have learning outcomes appropriate to the practical reflections on these experiences. Large-scale project studies involving biology teachers, consultant lecturers, and coordinator teachers may be developed to integrate reflective thinking into biology course curriculums. Studies can be done to improve reflective thinking of instructors and researchers as well as students. Efforts to examine the learning outcomes in Biology curriculum in terms of thinking skills are not at the desired levels. These studies need to reach the desired levels in terms of quantity and quality for improvement of Biology curriculums.

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