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

Ufuk Toman

Department of Mathematics and Science Education, Education Faculty, Bayburt University, Turkey

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 their actions, 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 |
| | Expects 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 and Subject                                                                 | Learning Outcomes                                                                 | Reflection Level          |
|---------------------------------------------------------------------------------|----------------------------------------------------------------------------------|--------------------------|
| 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                                                  | 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     |
| Community 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 | Explains 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 | Conducts experiments on aerobic respiration 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 grade, the fewest outcomes are 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.

REFERENCES

[1] Bahar, M. (2003). Biyoloji eğitiminde kavram yanlışlıklar ve kavram değişim stratejileri [Misconceptions and conceptual change strategies in biology education]. Kuram ve Uygulamada Eğitim Bilimleri, 3(1), 27-64.

[2] Berkant, H. G. (2007). Biyolojik kültür ve biyolojik bilinç yoluyla biyolojik düşünme [Biological thinking through biological culture and biological consciousness]. Çukurova Üniversitesi Eğitim Fakültesi Dergisi, 3(33), 1-6.

[3] MEB, (2018). Secondary School Biology Teaching Curriculum (9th, 10th, 11th, and 12th Grades) http://mufredat.meb.gov.tr/Dosyalar/20182215535566Biyo loji%20dop.pdf achieved on July 2018.

[4] Üstünoğlu, E. (2006). Üst düzey düşünme becerilerini geliştirmede bilisell soruların rolü [The role of cognitive questions in improving high-level thinking skills]. Çağdaş Eğitim Dergisi, 331, 17-24.

[5] Ersözü, Z. N. (2008). Yansıtıcı düşünceyi geliştirici etkinliklerin ilköğretim 5. sınıf öğrencilerinin sosyal bilgiler dersindeki akademik başarısaları ve tutumları etkisi [The impact of reflective thinking activities on the academic achievement and attitudes of 5th grade primary school students in Social Studies]. Unpublished doctoral dissertation, Fırat University, Elazığ.

[6] Van Manen, M. (1977). Linking ways of knowing with ways of being practical. Curriculum Inquiry, 6(3), 205-228.

[7] Dervent, F. (2012). Yansıtıcı düşünce menin beden eğitimi öğretmen adaylarının mesleki uygulamalarına etkisi [The effect of reflective thinking on the professional practices of physical education prospective teachers]. Unpublished doctoral dissertation, Marmara Üniversitesi, İstanbul.

[8] Wilson, J. and Jan, W. L. (1993). Thinking for themselves developing strategies for reflective learning. Australia: Eleanor Curtain Publishing.

[9] Akbari, R., Belzadpoor, F., and Dadvand, B. (2010). Development of English language teaching reflection inventory. Science Direct System, 38, 211-227.

[10] Hanton, S. and Smith, D. (1995). Reflective practice, experience, and the interpretation of anxiety symptoms. Journal of Sports Sciences, 2(5), 517–533.

[11] Hanton, S., Copley B., and Lee S. (2009). Reflective practice, experience, and the interpretation of anxiety symptoms. Journal of Sports Sciences, 2(5), 517–533.

[12] Demirören, M., Koşan, A. M. A., and Palağolu, Ö. (2009). Bir öğrenci ve değerlendirme yöntemi olarak “portfolyo” [“Portfolio” as a method of learning and evaluation]. Ankara Üniversitesi Tip Fakültesi Mevzuat, 62(1), 19-24.

[13] Pollard, A. (2005). Reflective teaching: evidence-informed practical practice. New York: Continuum.

[14] Balgalıus, E. and Baloglu, M. (2010). Eğitim yöneticilerinin düşünme stilleri açısından çesitli geçişli değişkenlere göre incelenmesi [Examination of education administrators according to various variables in terms of their thinking styles]. Hacettepe Üniversitesi Eğitim Fakültesi Dergisi, 38, 01–10.

[15] Quinn, L., Pultorak, E., Young, M., and McCarthy, J. (2010). Purposes and practises of reflectivity in teacher development. E. G. Pultorak (Ed.), The purposes practises and professionalism of teacher reflectivity. Maryland: Rowmann and Littlefield Education.

[16] Çepni, S. (2012). Araştırma ve proje çalışmalara giriş [Introduction to research and project studies]. Trabzon: Cepni Matbaacılık.

[17] Merriam, S.B. (2013). Nitel araştırma yöntemleri [Qualitative research methods]. Ankara: Seçkin Yayınları.

[18] Yıldırım, A. and Şimşek, H. (2013). Nitel araştırma yöntemleri [Qualitative research methods]. Ankara: Seçkin Yayınları.

[19] Miles, M. B. and Huberman, A. M. (2015). Nitel veri analizi [Qualitative data analysis] (1. Ed). (Çev. S. Akbaba Altun, Eleanor Curtain Publishing.
& A. Ersoy, Ankara: Pegem akademi yayınları.

[20] Bataineh, R. F., El Karasneh, M. S., Barakat, A. A., and Bataineh, R. F. (2007). Jordanian pre-service teachers’ perceptions of the portfolio as a reflective learning tool. *Asia-Pacific Journal of Teacher Education, 35*(4), 435–454.

[21] Senemoğlu, N. (2012). *Gelişim, öğrenme ve öğretim kuramdan uygulamaya* [Development, learning and teaching from theory to practice] (21. edition), Ankara: Pegem A Yayınları.

[22] Erginel, S. Ş. (2006). Developing reflective teachers: a study on perception and improvement of reflection in pre-service teacher education. *Orta Doğu Teknik Üniversitesi*, Unpublished doctoral dissertation, Ankara.

[23] Akay, C. (2005). *Ortaöğretim İngilizce dersinde okuma ve yazma becerilerinin kazandırılmasında oluşturmacılık temelli sosyal etkileşim modelinin öğrenciler üzerindeki etkilerinin incelenmesi* [Examining the effects of the constructivist-based social interaction model on the students in the acquisition of reading and writing skills in secondary school English lessons] Unpublished master’s thesis, Zonguldak Karaelmas University, Zonguldak.

[24] Ballard, K. K. (2006). Using Van Manen’s model to assess levels of reflectivity among preservice physical education teachers. Unpublished doctoral dissertation, Texas A and M University.