

UNDERSTANDING OF LIFE CYCLES AND FERTILIZATION DURING LEARNING BIOLOGY IN PRIMARY SCHOOL

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ABSTRACT

The aim of this study was to determine the conceptual understanding of the macro concept of Reproduction and organism development among students of the 7th and 8th grade of primary schools, based on students' answers to questions in relation to the macro concept of Reproduction and organism development at the regional competition in Biology in 2015 and 2017. Analysis of the students' answers included specific coding of the answers and interpreting the biological importance and meaning of each answer. Problems and misconceptions in relation to the concept of reproduction were singled out and explained. The analysis showed there is a problem with understanding the concept of reproduction and the misconceptions based around the key concept of cell life cycle, as well as misunderstandings of the concept of fertilization were observed as most prominent. Misconceptions found in this study show the necessity of changing the organization of contents taught in primary school biology and the need for using new teaching strategies, based on the students' activity and individual work.

Keywords: *conceptual understanding, macro-concept Reproduction and development of the organism, 7th and 8th grade (age 13 – 14), students' competition, problems and misconceptions*

INTRODUCTION

In Croatia, as well as in other countries, it was shown that during learning biology, students tend to be more successful solving questions which are examining their competences on lower cognitive levels (Garašić et al, 2013; Wood, 2009; Momsen et al, 2010). The cause of that can partially be the in the way that students are examined, because the examining teachers often make up questions of higher difficulty, but lower cognitive level and they find it hard to see the difference between the level of difficulty of a question and its cognitive level. When conceptual understanding is examined, the questions should be formed so that the ground concept for a certain field is the center, and the distractors should be developed so that they represent widely accepted misconceptions (Garvin-Doxas et al, 2007, according to Lukša, 2011). Tanner and Allen (2005) claim that students' wrong answers are the best tool in teaching and creating successful learning and acquiring knowledge. Because of that, it is important to examine students before learning new contents in order to determine their preconceptions and misconceptions, and to determine conceptual shifts at the end of the teaching and learning cycle.

The questions in the Regional competition in biology are connected to the contents of Biology in 7th and 8th grade of primary school, which are set by the National plan and programme for primary school (MZOŠ, 2006). Macro concept Reproduction and organism development is a part of the contents of teaching in subjects Nature and Biology, for students in 4th to 8th grade in primary schools.

The aim of this study was to analyze students' answers to questions in the written exam in Regional competition in biology in order to determine the conceptual understanding of macro concept Reproduction and organism development among students of 7th and 8th grade of primary schools. In order to accomplish the goal, this study aims to:

- ☞ determine the uniformity of evaluation of the regional and country commission in evaluation of students' answers
- ☞ analyse students' answers to determine the accuracy and level of understanding in each answer and to determine the meaning of the answer in the context of conceptual understanding
- ☞ determine the expected misconceptions for the macro concept Reproduction and organism development for Biology in 7th and 8th grade of primary school.

METHODS

The study was conducted in analyzing students' answers in the Regional competition in Biology for students of the 7th grade of primary school in 2017 and the answers of students in the 7th and 8th grade in the Regional competition in 2015, for the questions concerning the macro concept *Reproduction and organism development*. Twenty per cent of the most successful students' exams in each county were singled out.

For the questions that were chosen, each answer was evaluated by criteria in accuracy and level of understanding according to a adapted methodology by Radanović et al (2017a). A methodology of specific coding of biological meaning of correct and incorrect answers according to Radanović et al (2017b) was used for additional analysis and answer interpretation in the context of conceptual understanding of biological concepts.

The students were divided into success classes based on their percentile success in solving the exam in the Regional competition according to Radanović et al (2017a), which allowed determining misconceptions based off the incorrect answers in the written examination.

Statistical analysis and charts were made using Microsoft Excel and on-line StatsToDo. For determining distribution of the incorrect answers among the success classes for each question, χ^2 test (Chi Sq) was used, and the differences in frequencies for each student success class as well as partial answers were analyzed using Friedman two-way variance analysis for nonparametric data (F). Because of insufficiently large study sample, the classes of students which contained less than three students were not included in the analysis of determining misconceptions based on incorrect students' answers. The connection between variables was determined by correlation indexes, Pearson correlation index (r) for cases of linear correlation and normal distribution, and Spearman correlation coefficient (ρ) to determine the correlation of success in solving the exam and the cognitive level of the questions. Pearson's correlation coefficient was used to determine the correlation of evaluating students' answers in Regional competitions for regional and country commissions. The results of correlative connections were interpreted using a scale according to Hopkins (2000).

RESULTS AND DISCUSSION

For the macro concept *Reproduction and organism development* in the Regional competitions, there were 7 questions in total for the 7th grade exams in 2015 and 2017, and 9 questions in the 8th grade

exam in 2015. For 5 of those questions, problems during learning and teaching were determined as well as the possibility of misconceptions regarding the concepts of *cell life cycle* and *fertilization*.

For the macro concept *Reproduction and organism development*, no questions of the third cognitive level were included. The representation of key concepts within this macro concept is in accordance with the representation of the same key concepts in teaching contents for primary school Biology, and the questions were made to examine the learning outcomes set by the National plan and program for primary school (MZOŠ, 2006), and similar outcomes were also set by the examination catalogue for the State graduation exam (Radanović et al, 2015). The results support the conclusion made by Begić et al (2016), that there is an evident necessity to change the teaching program because of the unbalanced representation of macro concepts in biology. In addition, it is necessary to facilitate connecting biological disciplines supported by teaching subjects, in order to ensure conceptual building and systematization of conceptual understanding.

In biology teachers' expert councils, the teachers pointed out expected misconceptions that were seen at the end of primary school education of their students (Lukša et al, 2013). The teachers selected misconceptions: "the students do not know the difference between meiosis and mitosis"; "they do not know the difference between the number of chromosomes in body cells and reproductive cells"; "they make no connection between meiosis and mitosis with body and reproductive cells", which is to be used as a basis for comparison with the results of this study.

The questions for the 7th grade in 2015 and 2017 mostly examined the key concept of *cell life cycle*, but a portion of the answers only point to problems, but not misconceptions. For the expected misconception "they do not know the difference between the number of chromosomes in body cells and reproductive cells", the misconceptions were determined for the students examined in 2017. The same concept was examined in 2015 using a different type of questions and the same misconception was not found, but it was determined that the students lacked knowledge of the 1st and 2nd cognitive level. The results agree with the analysis made by Garašić (2012), which shows that the average acquired knowledge of biology among Croatian students are below 50 %, with the majority of knowledge being on the first cognitive level and the amount of knowledge acquired dropping as the cognitive level increases.

The expected misconception "they make no connection between meiosis and mitosis with body and reproductive cells" was not found among the student sample in this study. Overall, there is an accordance of the results of this study with earlier studies, in which the majority of problems that are related to the macro concept *Reproduction and organism development* concern the concept of *cell life cycle* (Lukša et al, 2016), and mostly relate to meiosis, specifically the importance of the change in the number of chromosomes in a cell undergoing meiosis. Considering the fact that cell divisions are repeated in learning biology in primary school and high school, and the same problems arise with students after completing high school education, the causes of these problems can be searched for in the traditional manner of teaching cell division, which often include very detailed descriptions of processes involved (Lukša, 2011; Lukša et al, 2016).

Some questions that are used to examine the roles of cell divisions can be solved incorrectly not because of the lack of understanding, but because of switching the names of cell divisions or forgetting them, which happens often with students, as Garašić (2012) points out. In a part of the 8th

grade student sample an incorrect thinking was observed, which claims that all the chromosomes in body cells are autosomes and the same mistake appears again in the 3rd and 4th grade of high school, according to Garašić (2012). The same study shows that 4th grade students show problems in making connections between the number of DNA molecules in human body and reproductive cells. This problem also appears among 8th grade students in the competition in 2015.

Successful students will continue to be successful, with no regards to the support received from their teacher, which is confirmed by results of Lugar and Mustač (2016), claiming that the most successful students in competitions are more successful in solving questions of higher cognitive levels, which is a consequence of conceptual understanding and understanding and application of causal links. Most 8th grade students that participated in regional competition show a good understanding of the number of chromosomes in a cell after mitosis and meiosis. In the national exams that were conducted in 2008, only 1/5 students answered correctly to several questions examining the concept (Radanović et al, 2010). Taking into consideration that only 20 % of the most successful students' exams in Regional competition of each county were analyzed, and the same students did show an understanding of the change in chromosome number during the *cell life cycle*, it can be said that the results of the two studies and in accordance and there is no large difference in understanding the number and structure of chromosomes in *cell life cycles* between the generations of students.

A part of 8th grade student participants in the Regional competition in 2015 showed wrong understanding of the fertilization process, which was tested with several questions in the written exam. In previous studies, there were no questions related to the concept of *fertilization* so no problems in understanding had been determined. Taking into consideration that this study included the answers of 20 % of most successful students in the Regional competition, the understanding of fertilization process should be tested in the entire generation of 8th grade students.

For the most part, macro concept *Reproduction and organism development* was represented with questions of 2nd cognitive level, or the level of application and conceptual understanding, in the regional competition. In solving more complex questions, students usually show partial conceptual understanding. The cause of that can be found in the way of learning and teaching biology which is still widely accepted in Croatian schools, which requires a large amount of reproductive knowledge that is only partially built up and made more complex in a higher cognitive level. In regional competitions, however, the recommended questions ratio is approximately 1/5 of questions in the 1st cognitive level, 2/3 in the 2nd cognitive level and 1/3 of questions in the 3rd cognitive level (Radanović et al, 2013). In all three written exams, students solved the questions of the 1st cognitive level the best, unrelated to the difficulty of the question, while the number of correct answers declines in the questions of higher cognitive levels (Begić et al, 2016; Lugar and Mustač, 2016). In this study it was shown that, despite the recommendations, questions in the 1st cognitive level still appear in regional competitions, which is to be avoided considering the participants are very successful students who have above-average results in their biology classes. However, a combination of 1st level questions that test key facts can be included in questions of higher cognitive levels, as shown in question 22 in the competition in 2015. Chosen questions for the Regional competition in biology for the 8th grade were related to the concept of heredity in organisms and in cells, as well as human reproduction. None of the chosen questions were of the 3rd cognitive level.

CONCLUSION

Students are better at solving questions of a lower cognitive level and the questions that do not require conceptual understanding. They are better at solving questions of a higher cognitive level if reproductive knowledge is sufficient for solving a part of the problem, or if elimination of incorrect answers and making logical conclusions can be used to determine the correct answer.

Several misconceptions were determined, and they are strongly related to the concept of *cell life cycle*. The students have most difficulties with understanding the role of mitosis and meiosis in growth, organism development and reproduction. Students have difficulties with connecting the key concept of *cell life cycle* with other key concepts in the macro concept *Reproduction and organism development*. Most incorrect answers relating to this macro concept stem from insufficient knowledge, wrong connections in creating knowledge and wrong understanding of the question, and not from misconceptions, which is related to problems in learning and teaching biology in the traditional methods of teaching in Croatian schools. 8th grade students show wrong understanding of the concept of *fertilization* and the relation of chromosomes and DNA molecules in a cell, which confirms the results of earlier studies.

Bad results are related to superficial mentioning of said concepts during learning and teaching biology, mostly in a traditional way of teaching and point to a necessity of change in creating biology classes and applying new teaching strategies that rely on students' independent work.

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