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# The presence of procedures that develop metacognition during teaching Biology

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**ABSTRACT**

Metacognition and its effects on learning and teaching are central topics in educational research. Numerous studies have shown that metacognitive teaching has positive effects on various areas of learning. In the Croatian educational system, metacognitive development is achieved through the implementation of the cross-curricular theme "Learning how to learn" in the immediate planning of the subject curriculum in all cycles of higher education. Given the planned systematic development of the same skill, the aim of the research is to determine the extent to which metacognition development practices are present in biology classes, and to identify which practices are predictors of overall success and achievement in Biology. The study involved 147 primary school students who completed a survey in which they rated the presence of Biology teacher procedures that lead to the development of metacognition during Biology class. The survey was analyzed using descriptive statistics. Pearson's correlation test was used to determine the correlation between the basic characteristics of the participants, such as grade level, gender, success in Biology, overall success, and the individual statements in the survey. Multiple regression analysis was also performed using teachers' practices (survey statements) taken predictors (independent variable) and success in Biology and overall success as criteria (dependent variable). On average, students believe that their teachers always apply certain procedures that promote students' metacognition, and the multiple regression analysis revealed that classroom atmosphere and formative assessment predict success in Biology.

***Keywords:*** *formative assessment, competence to learn how to learn; feedback; self-regulated learning*

## INTRODUCTION

Metacognition and its implications on learning and teaching have become a central question in educational research (Zohar & Barzilai, 2013). Numerous studies have shown that metacognitive training and instruction have positive effects in various areas of learning, such as reading, mathematical operations, and problem-solving (Zohar & David, 2008; Hattie, 2009). It is important to enable the development of metacognition in the school environment, which is achieved through various stimuli and activities such as direct instruction in metacognitive knowledge and/or skills, practicing the use of metacognitive knowledge and skills, and similar approaches (Ristić Dedić, 2019). Such metacognitive instruction is applied to improve students' metacognitive thinking, enhance problem-solving skills, or improve students' knowledge and conceptual understanding (Zohar & Barzilai, 2013). In the Croatian education system, metacognition is developed through the implementation of the curriculum expectations of the interdisciplinary theme "Learning how to learn." Although this curriculum was introduced into our education five years ago there is a potential dissonance between the theoretical and curricular provisions for teaching metacognition and the actual state in the school environment. It is important to systematically implement the expectations of the interdisciplinary theme "Learning how to learn" into the immediate planning of subject curricula, as well as (self)observation of how often and how successfully these expectations are implemented in Biology teaching. Therefore, the aim of this paper is to determine the extent to which metacognition-

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developing procedures are present during Biology teaching and to identify which procedures are predictors of overall success and success in Biology.

## MATERIALS AND METHODS

In the research conducted in the school year 2022/2023, 147 elementary school students participated. A survey was conducted with the participants, which included 41 closed-ended questions (statements). 4 questions determined the grade level, gender, performance in Biology, and overall performance of the students. 37 statements assessment the representation of Biology teachers' practices that lead to the development of metacognition during Biology teaching. The formulation of the survey statements (Table 1) was based on the protocol of the Teaching Observation Form (TOF form, Bezinović et al., 2012) and the analysis of the Curriculum for the interdisciplinary topic Learning How to Learn for primary and secondary schools in the Republic of Croatia (MZO, 2019).

**Table 1. Presentation of survey statements categorized according to the original TOF form**

| **Classroom atmosphere** |
|---|
| The teacher treats students with respect and acceptance (RO1) |
| The teacher praises students' efforts and achievements (RO2) |
| **The teacher emphasizes trust in students' abilities and success (RO3)** |
| **Structuring of the lesson** |
| At the beginning of the lesson, the teacher clearly states the topic of the lesson (SN4) |
| **At the beginning of the lesson, the teacher encourages the evocation of relevant prior knowledge for the lesson topic (SN5)** |
| **At the end of the lesson, the teacher encourages the recognition of changes in knowledge compared to the beginning of the lesson (SN6)** |
| **At the beginning of the lesson, the teacher places the lesson topic in the context of general life knowledge and highlights practical, historical, or affective values of learning the lesson topic (SN7)** |
| The teacher clearly states the objectives of the lesson (learning outcomes) (SN8) |
| **The teacher encourages the assessment of the effectiveness of learning methods for achieving the objective (SN9)** |
| **The teacher outlines the lesson plan (describing how to learn or achieve the objective) (SN10)** |
| At the end of the lesson, the teacher briefly summarizes what was done and how it was done in the lesson (SN11) |
| **Student involvement and motivation** |
| Students are actively engaged in work (MO12) |
| **The teacher encourages students to independently set their own goals for the lesson (MO13)** |
| **The teacher promotes collaborative learning (MO14)** |
| Students freely express their ideas, ask questions, or seek clarification (MO15) |
| The teacher encourages students to provide their own examples related to the content being learned (MO16) |
| **Individualization/differentiation of teaching** |
| The teacher assigns tasks of different difficulty to students with different abilities or interests (IN17) |
| The teacher provides the opportunity to choose activities and work methods (IN18) |
| **Teaching metacognitive skills and learning strategies** |
| The teacher emphasizes understanding, not just memorizing concepts (M19) |
| The teacher asks questions that stimulate thinking (that stimulate higher-level cognitive processes) (M20) |
| The teacher directly teaches students how to approach learning, solving specific tasks, or practicing (M21) |
| **The teacher models the use of different metacognitive strategies and activities in specific contexts (M22-24)** |
| **The teacher encourages students to explain why a specific approach was chosen when solving a task (M25)** |
| **The teacher provides the opportunity for independent practice of using metacognitive strategies on different tasks (M26)** |
| The teacher encourages students to express in their own words how they have understood the content being learned (M27) |
| The teacher encourages students to monitor and check their work (e.g. identifying and correcting mistakes, checking the solution they have reached) (M28) |
| The teacher encourages students to independently take notes and organize the content being learned (e.g. by highlighting main ideas and concepts or creating simple representations) (M29) |
| **The teacher asks questions and encourages discussion about the metacognitive experience of the lesson topic or task (e.g. whether they feel confident, unprepared, scared, calm, etc.) (M30)** |
| **The teacher sets an example of thinking and approaches that contribute to a positive attitude towards the lesson topic and learning (M31)** |
| **The teacher sets an example of thinking and approaches that contribute to reducing stress or negative attitude towards the lesson topic or learning (M32)** |
| **Feedback and formative assessment of learning** |
| The teacher asks questions to check students' understanding (FV33) |
| **The teacher encourages the student to monitor their understanding during the lesson and react as needed (FV34)** |
| The teacher provides specific feedback to students about their work (FV35) |
| **The teacher encourages and supports the student to create internal feedback (FV36)** |
| The teacher explains their criteria for evaluating students' work and achievements using concrete examples (FV37) |

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The survey results were analyzed using descriptive statistics, where the mean value and standard deviation of students' responses to each survey statement were expressed. The correlation between class, gender, Biology achievement, and overall achievement with each survey statement was determined using Pearson's correlation test. The results were presented in tabular form, with the statements grouped within tables according to the previously described labels. Multiple regression analysis was also performed, where the teacher's actions (survey statements) were taken as predictors (independent variable) of Biology achievement and overall achievement as the criterion (dependent variable). Only those models in which a statistically significant relationship between the dependent variable and the set of independent variables (F ratio) was found are presented in the results. The statistical package SPSS 20.0 (IBM Corp., Armonk, NY, USA) was used for all analyses.

## RESULTS

On average, students perceive that their teachers always treat them with respect and acceptance (RO1), always praise their efforts and achievements (RO2), and always express confidence in their abilities and success (RO3). The teacher's behavior of treating students with respect and acceptance (RO1) is a significant predictor of success in Biology among primary school students ($\beta = 0.223$, $p = 0.016$). Students on average estimate that their teachers always clearly state the topic of the lesson at the beginning of the class (SN4), encourage the evocation of relevant prior knowledge for the lesson topic (SN5), place the lesson topic in the context of general life knowledge (SN7), clearly state the objectives of the lesson (SN8), and encourage the assessment of the effectiveness of the learning methods for achieving the objective (SN9). On average, students respond that their teachers always encourage them to set their own goals for the class (MO13), always encourage collaborative learning (MO14), free expression of ideas, asking questions, and seeking clarification (MO15), and always encourage them to provide their own examples related to the content being learned (MO16). On average, students estimate that they are sometimes actively involved in the work (MO12). A statistically significant correlation was found between gender and the 16th statement (MO16), as well as between the same statement and success in Biology. Students on average respond that their teachers sometimes give tasks of different difficulty to students with different abilities or interests (IN17) and sometimes give the opportunity to choose activities and ways of working (IN18). Only to one statement related to teaching metacognitive skills and learning strategies, students on average respond with sometimes (M30) while to the other statements they respond with always on average. Students on average estimate that all procedures related to formative assessment are always present in the classroom. Practice of the teacher encouraging students to monitor their understanding and react as needed during class (FV34) is a significant predictor of success in Biology among elementary school students ($\beta = 0.205$, $p = 0.046$). The same predictors' F ratio for overall success is not statistically significant.

## DISCUSSION

According to the estimates of primary school students involved in the research, the procedures for developing metacognition in students are represented during Biology teaching. Almost all procedures for developing metacognition during Biology teaching are perceived by students as always present on average. According to the conducted research, the predictive procedures for success in Biology are the procedures related to the classroom atmosphere and those related to formative assessment. This research did not identify predictive procedures for overall success. In the classroom atmosphere model, a statistically significant predictor of success in Biology is the procedure in which the teacher treats students with respect and acceptance. According to McGuire (2023) overall classroom

atmosphere contributes to the development of metacognition. The procedure in which the teacher encourages students to independently set their own goals for the lesson (MO13, Table 1) is important for the development of metacognitive skills in goal setting and learning organization. Setting their own goals for the lesson serves as practice for metacognitive skill acquisition, which is crucial for its adoption (Veenman, 2015), but it also increases students' motivation and willingness to work (Zimmerman, 2008). On average, students evaluate this procedure as one that is always present during Biology teaching. However, compared to the results of Labak et al. (2024), this procedure is not always present in lessons. The procedures examined by the survey statements related to teaching metacognitive skills and learning strategies (M19 to M32, Table 1) are procedures that teachers mostly always apply in their teaching according to students. According to Labak et al. (2024), these procedures are not often present in Biology lessons. It is necessary to explicitly plan the practice of metacognitive skills in the lesson (Ristić Dedić, 2019) and practice them over a longer period (Cubukcu, 2008). According to Nicol & Macfarlane-Dick (2006), formative assessment can promote self-regulated learning and metacognitive skills. The presence of the self-evaluation procedure in this study was assessed as well-presented, while according to the study by Labak et al. (2024), it was not.

## CONCULSION AND METODOLOGICAL SIGNIFICANCE

Estimates from students involved in this research indicate teaching practice from their perspective. Since a smaller number of primary school students were included in the research and only a survey was used, it is not possible to draw conclusions about the actual practice for the development of metacognition based on this research. It is possible that the examined procedures appear individually, rather than as a set of procedures in one lesson, so students identified them as always present. Our similar research, which included the analysis of lessons, showed a weak representation of procedures for the development of metacognition. Therefore, further research of this nature and purpose is necessary due to the importance of metacognition and its impact on the learning process and effectiveness, which would ultimately help and guide the professional development of teachers in the segment of metacognition development within teaching specific curricula. In this development, survey statements can help as suggestions for procedures, incentives, and activities for the development of metacognition in students.

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