EdBi Educatio Biologiae Extended summary

Received 21.10.2024.
Accepted 27.10.2024.
Published 28.11.2024.

Assessment of Scientific Literacy Development through Biology Teaching and Proposal of Tools for (Self-)Evaluation and Improvement of Such Teaching

Ozrenka Meštović1, Jasenka Meštrović2, Irena Labak3

[1] Primary school „A. G. Matoš“, Ohridska 21, Vinkovci, Croatia ozrenka.mestrovic@skole.hr

[2] Primary school Vođinci, Slavonska 21, Vođinci, Croatia jasenka.mestrovic@skole.hr

[3] Biology Department, Josipa Jurja Strossmayera University at Osijek, Emperor Hadrijan street 8/A, Osijek, Croatia ilabak@biologija.unios.hr

ABSTRACT

Although subject curricula that promote the development of scientific literacy have been present in Croatian education for five years, the results of external evaluations indicate insufficient development of this literacy among pupils. This highlights the relevance of researching this topic, and the aim of this study is to determine how much scientific literacy is developed during the teaching of Biology to 8th-grade pupils. For the purposes of the research, the original teaching observation form (OZON form) was analyzed and modified, and video recordings of lessons taught by seven teachers who teach Biology in the 8th grade were analyzed using this form. The results of the video analysis indicate an insufficient presence of activities and stimuli that promote the development of scientific literacy. Since scientific literacy is a complex construct that encompasses various knowledge and skills, teaching for its development requires diverse stimuli to actively engage pupils, from involving them in inquiry and reasoning to self-assessment. Therefore, the original form, with the proposed modifications, is a valuable tool for the (self-)evaluation of teaching aimed at promoting pupils' scientific literacy and for guiding teachers' professional development.

Keywords: *video analysis; curriculum; lesson observation form; professional development; teachers*

INTRODUCTION

Scientific literacy has long been subject to various conceptual considerations arising from scientific, technological, social, and political changes that have characterized modern society (Costa et al., 2021). According to Hurd (1998), Costa et al. (2021), and the relevant Biology curriculum (MZO, 2019), scientific literacy encompasses research skills and learning through imitation of scientific methodology, as well as an understanding of the interrelationship between science and society. This literacy develops through the teaching of Biology and other subjects in the natural sciences.

A method that literature suggests is suitable for the development of scientific literacy is research-based learning (Heppt et al., 2023; Oktaviani & Faizah, 2024), which follows steps similar to scientific methodology, from formulating hypotheses to testing those hypotheses and drawing conclusions based on results (Heppt et al., 2023).

Scientific literacy is assessed through the PISA assessments (Programme for International Student Assessment). PISA tasks evaluate how successfully pupils can apply knowledge and skills in new and unfamiliar situations (Braš Roth et al., 2017). Croatian pupils generally achieve lower results than the OECD average in all cycles of research since their participation began (NCVVO, 2023), even in the latest cycle when curricula aimed at developing scientific literacy have already been implemented. A probable cause is that teachers poorly recognize and/or apply activities that promote the development

Meštrović, O; Meštrović, J; Labak, I. 2024. Assessment of Scientific Literacy Development through Biology Teaching and Proposal of Tools for (Self-)Evaluation and Improvement of Such Teaching. Educ. biol., 10:60-63. https://doi.org/10.32633/eb.10.3

URL DOI: https://doi.org/10.32633/eb.9.2

of scientific literacy, or they less frequently provide pupils with incentives achievable in every lesson that are crucial for its development.

Therefore, the aim of this paper is to determine how much scientific literacy develops during Biology teaching for 8th-grade pupils. To achieve this goal, the original OZON observation form was analyzed and modified, and video recordings of Biology lessons were analyzed using this form. Additionally, this paper aims to discuss the relevance of the OZON protocol in observing teaching that promotes the development of scientific literacy, to highlight aspects for improving teaching that fosters pupils' scientific literacy, and to propose a tool for (self-)evaluation of teaching that develops scientific literacy.

METHOD

The research involved seven teachers who teach Biology to 8th-grade pupils. During the study, video recordings of their lessons were analyzed, totaling seven hours of Biology instruction (one lesson from each teacher). For the purposes of the research, the original lesson observation form (OZON form, originally adapted from Bezinović et al., 2012) was first analyzed and modified, after which the video recordings of the Biology lessons were assessed according to the modified OZON form.

The analysis of the OZON form included identifying features that explicitly contribute to the development of pupils' scientific literacy in Biology teaching. The modification of the form involved adding features that, along with the existing ones, allow for the analysis of Biology instruction that fosters scientific literacy. Each lesson was analyzed according to the modified OZON form by two independent researchers and the teacher themselves. The reliability between the researchers and between the researchers and the teacher was determined using Cohen's Kappa coefficient, which can range from 0 (no agreement between raters) to 1 (excellent agreement between raters) (Landis & Koch, 1977).

RESULTS

The feature *"The teacher clearly states the objectives of the lesson (learning outcomes)"* is poorly represented in the lessons (absent in five teachers). This feature from the original OZON form is marked as one that explicitly develops scientific literacy. The feature *"Pupils freely express their ideas, ask questions, or seek clarification"* is fully present in the lessons of two teachers. However, the encouragement for pupils to recognize/formulate research questions, to express their own hypotheses about the results of experiments, and to draw conclusions independently based on experiments is completely absent among all analyzed teachers, according to both subjective and objective assessments.

The encouragement for verbalizing observed processes, phenomena, and cause-and-effect relationships is not fully represented in any teacher's lessons, and only partially in four of them. These features were also added to the original OZON form. All features related to teaching metacognitive skills and learning strategies in the original OZON form (as shown in Table 1 of the study) are marked as those that explicitly develop scientific literacy. Among these, the least represented (absent or insufficiently present in the majority of teachers) is direct instruction to pupils on how to approach learning, solving specific tasks, or practicing; encouragement for monitoring and checking their own work; encouragement for self-assessment and progress evaluation; urging pupils to express their personal opinions and critically reflect on the content being learned; assigning tasks that allow the

URL DOI: https://doi.org/10.32633/eb.9.2

application of knowledge or skills to everyday situations; encouragement for independent note-taking and organizing learned content; and connecting content from different subjects.

One aspect that no teacher requires from pupils is to describe and explain the steps they use in working on a task. Among all the features related to feedback and formative assessment of learning (which are also marked as those that explicitly develop scientific literacy, as shown in Table 1 of the study), the least represented (absent or insufficiently present in the majority of teachers) is providing concrete feedback to pupils about their work and highlighting pupils' progress and success in learning. Furthermore, the explanation of assessment criteria and pupils' achievements using specific examples was absent in all analyzed teachers' lessons.

DISCUSSION, CONCLUSIONS AND DIDACTIC SIGNIFICANCE

This research was conducted with the intention of providing a way to (self)assess the development of scientific literacy through Biology teaching. Given that this literacy is a complex construct, the study examines the modified OZON protocol, which allows for comprehensive monitoring of teaching, including classroom atmosphere, lesson structure, active pupil engagement, and self-assessment, along with related metacognition. The protocol was supplemented with prompts that characterize inquiry-based learning.

The analysis of video recordings of Biology lessons according to the modified OZON form revealed a weak development of scientific literacy through Biology teaching. This result aligns with the PISA findings, which show that Croatian pupils generally achieve lower results than the OECD average. In the most recent assessment in 2022, a noticeable decline was observed at both testing levels, with the average score of our pupils being 483 points, compared to the OECD average of 485 points (NCVVO, 2023).

In 2022, a curricular approach was introduced into Croatian education, marking the fourth year of implementing subject-specific and interdisciplinary curricula aimed at developing scientific literacy. Such results indicate that the curriculum alone is not sufficient for fostering scientific literacy among pupils; rather, a change in teachers' awareness is needed (Labak, 2022), which can drive changes in teaching practices aligned with the curriculum. Changes in awareness are linked to professional development, which should be viewed from two aspects: i) the effectiveness of organized professional gatherings and ii) teachers' readiness to embrace changes and adapt their usual teaching practices accordingly.

The effectiveness of professional development programs depends on various factors, such as teachers' working conditions, available teaching materials, school administration support, and informal learning processes among teachers (Asterhan & Lefstein, 2024). Desimone (2023) emphasizes that professional development programs should help teachers become experts in recognizing the needs of each pupil. Labak (2020) highlights that teachers need to identify their own improvement needs based on the analysis of their teaching. The practice of self-reflection and targeted professional development can influence teachers' readiness to accept changes and consequently modify their usual teaching practices.

This research has established that scientific literacy develops poorly among 8th-grade pupils during Biology teaching. Given the variety of teaching characteristics monitored by the OZON form, scientific literacy, as a complex construct, can be tracked with minor modifications. The weak representation of

URL DOI: https://doi.org/10.32633/eb.9.2

certain characteristics indicates the necessity for further research of this nature, which would guide the professional development of teachers in the area of developing scientific literacy within their teaching practice.

The curriculum alone is not sufficient for effective scientific literacy development; teachers need to identify their own improvement needs to enhance teaching practices that foster pupils' scientific literacy. The proposed modified OZON form for monitoring the development of pupils' scientific literacy serves as a tool that enables a proactive approach to professional development as a self-directed process.

REFERENCES

Asterhan, C. S. C., & Lefstein, A. (2024). The search for evidence-based features of effective teacher professional development: A critical analysis of the literature. *Professional Development in Education, 50(1),* 11–23. https://doi.org/10.1080/19415257.2023.2283437

Bezinović, P., Marušić, I., & Ristić Dedić, Z. (2012). *Opažanje i unapređivanje školske nastave [Observing and improving school teaching].* Agencija za odgoj i obrazovanje [Education and Teacher Training Agency].

Braš Roth, M., Markočić Dekanić, A., i Markuš Sandrić, M. (2017). *PISA 2015: Prirodoslovne kompetencije za život.* Zagreb: Nacionalni centar za vanjsko vrednovanje obrazovanja – PISA centar.

Costa, A. M., Ferreira, M. E., & Loureiro, M. J. da S. (2021). Scientific Literacy: The Conceptual Framework Prevailing over the First Decade of the Twenty-First Century. *Revista Colombiana de Educación, 81,* 195–228.

Desimone, L. M. (2023). Rethinking teacher PD: A focus on how to improve student learning. *Professional Development in Education, 49(1),* 1–3. https://doi.org/10.1080/19415257.2023.2162746

Heppt, B., Henschel, S., Hardy, I., & Gabler, K. (2023). Instructional support in inquiry-based elementary school science classes: How does it relate to students' science content knowledge and academic language proficiency? *European Journal of Psychology of Education, 38(4)*, 1377–1401. https://doi.org/10.1007/s10212-022-00653-6

Hurd, P. D. (1998). Scientific literacy: New minds for a changing world. *Science Education, 82(3),* 407–416. https://doi.org/10.1002/(SICI)1098-237X(199806)82:3<407::AID-SCE6>3.0.CO;2-G

Labak, I. (2020). Upravljanje razvojem pedagoških kompetencija [Managing the development of pedagogical competences]. *Školski vjesnik: Journal of Pedagogic Theory and Practice, 69(2),* 461–480. https://hrcak.srce.hr/249030

Labak, I. (2022). Unaprjeđivanje metakognitivne dimenzije kompetencije učiti kako učiti kod učitelja. [Improving the metacognitive dimension of competence to learn how to learn in students and teachers]. *Napredak: Journal of Interdisciplinary Research in Education, 163(1–2),* 181–199. https://hrcak.srce.hr/279091

Landis, J. R., & Koch, G. G. (1977). The measurement of observer agreement for categorical data. *Biometrics, 33(1),* 159–174. https://doi.org/10.2307/2529310

Ministarstvo znanosti i obrazovanja (2019). *Odluka o donošenju kurikuluma za nastavni predmet prirode za osnovne škole u Republici Hrvatskoj.* Zagreb: Ministarstvo znanosti, obrazovanja i sporta RH. Dostupno na https://narodne-novine.nn.hr/clanci/sluzbeni/2019_01_7_148.html

Nacionalni centar za vanjsko vrednovanje (2023). *PISA 2022: rezultati, odrednice i implikacije Međunarodno istraživanje znanja i vještina učenika.* Zagreb: Nacionalni centar za vanjsko vrednovanje obrazovanja – PISA centar. Preuzeto 25. rujna 2024, s https://www.ncvvo.hr/wp-content/uploads/2023/07/TIMSS_Medjunarodno-istrazivanje-ciklusi-2011-15-19_F.pdf

Oktaviani, N., & Faizah, U. (2024). The effect of science literacy skills to contextual thinking skills on science Literacy-based learning. *INSECTA: Integrative Science Education and Teaching Activity Journal, 5,* 1–10. https://doi.org/10.21154/insecta.v5i1.8852