

Media in education & Education in the media



Uniwersytet
Komisji Edukacji Narodowej
w Krakowie
Kraków 2024

Media in education & Education in the media

**University of the National Education Commission, Krakow
2024**

**Media in education
&
Education in the media**

**editor
Małgorzata Nodzyńska-Moroń**

**University of the National Education Commission, Krakow
2024**

Scientific editing:

Małgorzata Nodzyńska-Moroń

Rewievers:

Vladimir Sirotek

Wioleta Kopek-Putała

Cover:

Małgorzata Nodzyńska-Moroń

e-ISBN 978-83-68020-41-0

ISBN 978-83-68020-40-3

DOI 10.24917/9788368020403

Uniwersytet Komisji Edukacji Narodowej

30-084 Kraków, Polska

Printing and blinding

Zespół Poligrafii Wydawnictwa Naukowego

UKEN

Introduction

In the digital age, the symbiotic relationship between media and education has become an integral facet of the learning landscape. The book “Media in Education & Education in the Media” delves into the multifaceted intersections of media technologies, educational practices, and their collective impact on shaping the learning experience. Each chapter in this collection navigates a diverse array of topics, examining how media influences education and, reciprocally, how education utilizes media to enhance learning outcomes.

The journey begins by exploring the integration of 3D printing technology in primary schools, shedding light on its transformative potential in the context of empirical research. As we delve into the chapters that follow, the book embarks on a captivating exploration of the role of multimedia in shaping students’ attitudes towards critical issues, such as air pollution and waste segregation. These chapters not only uncover the depth of student knowledge but also underscore the pivotal role that media plays in transforming perspectives and fostering environmental consciousness.

Artificial intelligence takes center stage in the subsequent chapter, unraveling its integration into the daily work of teachers. The narrative explores how AI augments teaching methodologies, presenting a nuanced perspective on its applications and implications within the educational landscape.

The seismic disruptions caused by the COVID-19 pandemic form the backdrop for a case study analyzing the pass rates of students in Chemistry teaching at final state exams. This chapter scrutinizes the influences of stress during distance learning, providing valuable insights into the challenges and adaptations within the educational system during times of crisis.

The exploration extends to the realm of science education with the examination of USB-microscopes in chemistry and geology. The authors dissect whether these tools are perceived as mere toys for enthusiasts or essential aids in the pedagogical toolkit, emphasizing the importance of incorporating technology in the teaching of scientific subjects.

Virtual Reality (VR) emerges as a powerful tool in the teaching of chemistry, offering immersive and interactive experiences for learners. This chapter investigates the effectiveness of VR in enhancing chemistry education, opening new dimensions for engaging students in complex scientific concepts.

GeoGebra tools take the spotlight as facilitators of algorithmic learning in the next chapter. The book explores how these tools support the development of algorithmic thinking, emphasizing the practical applications of technology in fostering mathematical literacy.

Formative assessment finds a digital ally in the “Digilib” digital library, illustrating how modern libraries evolve to meet the changing needs of educators and learners. This chapter highlights the integration of technology to enhance formative assessment practices, providing a dynamic platform for continuous learning.

The concluding chapters delve into the antecedents of the perceived usefulness of online learning platforms during the pandemic, offering a reflective analysis on the evolving landscape of digital education. The book concludes with a unique perspective on Slovak journalism’s role in science communication, emphasizing the vital link between media and the dissemination of scientific knowledge.

“Media in Education & Education in the Media” seeks to unravel the intricate dance between these two dynamic realms, offering a tapestry of insights, analyses, and practical applications. As we embark on this exploration, we invite readers to delve into the evolving landscape where media and education converge, offering new possibilities for transformative learning experiences.

Małgorzata Nodzyńska-Moroń

Support training in algorithmization using GeoGebra tools

Věra Ferdiánová, Marek Bukovský, Jakub Poruba

[DOI 10.24917/9788368020403.1](https://doi.org/10.24917/9788368020403.1)

Abstract

Digital competences are a theme that resonates throughout the education system and is currently being emphasised. One of its goals is to increase the implementation of computer science in education. It is therefore not just about computing subjects, but about using digital competences as a cross-curricular theme across all subjects (NPI, 2021).

The teaching of mathematics directly lends itself to the use of computer science in the teaching of geometry or statistics through the various use of quizzes, other interactive materials or detailed instructional videos. In mathematics, GeoGebra software is widely used not only for teaching geometry, but also as an excellent visualization and logic tool across all mathematical domains. GeoGebra allows you to create custom tools that work on the principle of a compiled algorithm and are primarily used in the context of solving design problems.

The aim of this paper is to show how this tool can be used as a motivator of students' algorithmic thinking, and also to introduce it as a useful tool in the creation of interactive materials in the teaching of planimetry. The paper will also introduce parts of planimetric geometry that can be algorithmized to create a new tool within the GeoGebra software. The second part has already been implemented in the thesis of our student Marek Bukovsky (2023), who created tools that were subsequently used in the solution of planimetric problems.

Keywords:

algorithm, algorithmization in geometry, GeoGebra, planimetry

Introduction

Electronic technologies (computers, tablets, calculators) are now essential tools in mathematics education. They provide visual images of mathematical ideas, facilitate the organisation and analysis of data and help us to calculate efficiently and accurately. They can support students in any area of mathematics, including geometry, statistics, algebra and more. With the accessibility of technology tools, students can focus on decision making, reflection, reasoning, and problem solving. Appropriate use of these technologies can also lead to a deeper understanding of mathematics. In any case, technology should not, at any point, completely replace basic mathematical practices and intuition. On the contrary, it should serve to support them. The use of mathematical programmes must be responsible with the aim of enriching students' learning (NCT, 2000).

Cognitive technologies used in mathematics education can be divided into the following categories (Vaníček, 2009):

- Computer algebraic systems applications that focus on numerical and symbolic calculations. They show numerical results accurately and not in a rounded way like a calculator. We can do really high mathematics with them. Specific representatives are, for example, Matlab or Maple.

- Dynamic geometry environment programs with which we can create geometric constructions. Their function is to draw quickly and efficiently. They also allow us to manipulate the features. The best known representatives are, for example

GeoGebra, Cabri

- Microworlds are a gateway to a different way of looking at geometry that focuses on algorithmization. Here, graphics are created by entering a sequence of commands to draw a graphical object. The so-called “turtle graphics” are well known, in which we're trying to program a turtle to draw shapes. This can be programmed either by dragging and dropping graphic blocks or textually.

Teaching Algorithms in the framework of the RVP

The teaching of algorithms in primary schools in the Czech Republic was not very widespread in the past, mainly due to limited technical resources and the focus of teaching on basic educational objectives, as the teaching of algorithms was rather integrated into the content of technical high schools and selected computer science seminars at grammar schools. The modern meaning of an algorithm in primary school can be likened to, for example, a cooking recipe, instructions for making simple objects, procedures, etc. According to Knuth, however, an algorithm can be defined as a finite set of rules that describe a sequence of operations for solving a certain type of problem, but it must also satisfy five important properties:

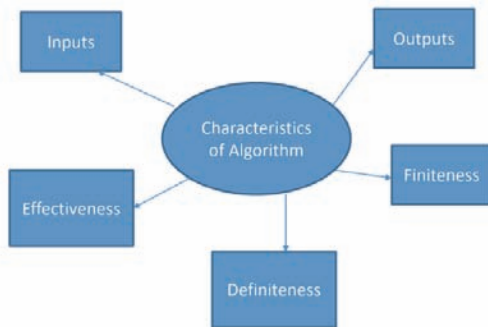


Figure 1. Characteristics of Algorithm

1) Finiteness: The algorithm must always terminate after a finite number of steps (Knuth, 2008). For example, if we want to draw a Thalet circle, we know that after finding its center and radius, the desired circle will be drawn. We will consider the steps of the algorithm to be the construction steps.

2) Definiteness: Each step of the algorithm must be precisely defined and for each case it must describe the operations performed with certainty and unambiguity (Knuth, 2008). From the point of view of geometry, these are basic construction procedures of the form draw a line segment AB, draw a circular arc of a given radius and center, find the intersection of two figures, etc.

3) Input: Each algorithm has zero or more inputs: these are variables that we enter into the algorithm before it starts or that we load dynamically on the fly. These inputs are taken from a specified set of objects. If we want to algorithmically construct a Thalet circle, then the input will be the line segment AB or just the specified points AB over which we construct the Thalet circle.

4) Output: An algorithm also has one or more outputs: these are quantities that have a specified relationship to the inputs (Knuth, 2008). In our case, for the construction of the Thalet circle, the output is the search circle that satisfies the specification.

5) Efficiency: The algorithm should also be efficient, which means that all its operations must be reasonably simple, so that in principle anyone with a pencil and paper should be able to perform them accurately and in finite time (Knuth, 2008). This is exactly what is used in solving design problems.

However, in recent years there has been an interest in introducing elements of algorithm learning in primary schools so that students are introduced to this important concept from an early age.

Here are some ways in which algorithms teaching can be implemented in primary schools:

Basic programming: some schools and curricula have started to introduce basic programming as early as primary school. This may include learning simple programming languages or block-based visual programming tools.

Logical thinking and algorithmic problems: Teaching may include tasks aimed at developing logical thinking and solving algorithmic problems. This may include a variety of puzzles, riddles, and simple problems that help students understand the basic concepts of algorithms.

Robotics and creative projects: some schools may incorporate robotics into the curriculum, which can be a fun and hands-on way to introduce students to algorithmic thinking (Žáček, 2019). Students can program robots and control their movements and actions using simple algorithms.

Online resources and interactive games. These tools often combine education with playfulness, which can increase student interest.

Project-based learning: Some schools may introduce project-based learning, in which students participate in specific projects that involve the design and implementation of simple algorithms.

It is important to note that the level and extent of algorithm teaching in primary schools may vary between schools and regions. In addition, teaching may evolve depending on technological advances and pedagogical trends.

In 2023, the revised FEP for primary schools came into force (NPI, 2018). With interesting changes in the revision of ICT teaching, as the teaching of office packages can be moved to other subjects and the teaching of algorithmic and logical thinking with output to any programming language is preferred within computer science. Within our proposed changes we have prioritized the area of ALGORITHMIZATION AND PROGRAMMING where the Expected Learner Outcomes are:

I-9-2-01 after reading the individual steps of an algorithm or program, explain the entire procedure; identify the problem that is solved by the algorithm

I-9-2-02 divides the problem into individually solvable parts and proposes and describes the steps to solve them

I-9-2-03 selects an appropriate algorithm for the problem to be solved from among several options and justify the choice; modify the algorithm for other problems; propose different algorithms for solving the problem

I-9-2-05 creates a clear program in a block-oriented programming language, taking into account its possible consequences and his/her responsibility for them; tests the program and corrects any errors in it; uses repetition, program branching, variables I-9-2-06 verifies the correctness of the procedure, finds and corrects any errors in it.

The content of the Algorithmization curriculum should be the decomposition of a problem; creation, writing and adaptation of a programming algorithm; tools of the programming environment, block-oriented programming language, cycles, branching, variable control; Verifying the algorithm, program (e.g., by changing inputs, checking outputs, rerunning); finding bugs (e.g., by stepping); modifying the algorithm and program creating digital content: creating programs (e.g., stories, games, simulations, robots); user needs, program user interface; program authorship and licensing; programmer ethics.

With regard to the ongoing trends of digitalization and the introduction of new computer-based education in all types of schools, it is necessary to take into account the possible changes in the traditional approach to mathematics education and to transfer it more into digital form in order to take advantage of the opportunities that digitalization brings and thus support the development of digital competence. So far, digital competence has been formally introduced in primary education in the newly revised Framework Education Programmes, but it is to be expected that it will be introduced in a similar vein in higher education. The digital competences are defined in the FEP for elementary education as follows:

At the end of primary education, the pupil: is proficient with commonly used digital devices, applications and services; uses them for learning and for engagement in school and society; makes independent decisions about which technologies to use for which activities or problems obtains, searches, critically assesses, manages and shares data, information and digital content, choosing the processes, methods and means appropriate to the situation and purpose creates and edits digital content, combines different formats, expresses themselves using digital means uses digital technologies to facilitate work, automate routine activities, streamline or simplify workflows and improve the quality of their work understands the importance of digital technologies for human society, learns about new technologies, critically evaluates their benefits and reflects on the risks of their use avoids situations threatening the security of equipment and data, situations with negative impact on his/her physical and mental health and the health of others; acts ethically when collaborating, communicating and sharing information in the digital environment.

Microlearning can be used to support the development of these competences.

Microlearning can be understood by its name as a way of learning in small steps; learning that takes only a few minutes of time. Around 5 minutes is commonly cited as such a limit. Its aim is always to cover a specific learning need. In this way, learning as such can be spread out according to individual learning needs, with the learner choosing the pace of learning. Due to its time span, it is also possible to divide the necessary material into short sub-sections, which should lead to better retention of the material (Polasek, 2019; Javorčík, 2023).

For its application, it is possible to use a wide range of multimedia means, nowadays ideally usable on tablets and other mobile devices. These mini-lessons can take different forms - text, images, videos, vlogs, digital apps.

One of the areas where microlearning and digital competence development can be combined is plane geometry, especially its construction part. In fact, in construction geometry, we often work by using sub-algorithmic steps to represent the resulting construction. With the use of graphical software such as GeoGebra, it is by setting up algorithmic steps that we are able to automate (the so-called creation of New Tools) and streamline workflows, while using appropriate technology to solve the problem.

GeoGebra and the creation of the Custom Tool

GeoGebra is a tool primarily designed for dynamic geometry, but it has a wide range of uses. The advantage of this software is the ability to create your own missing tools that are not available by default in GeoGebra. This gives us a variable space that we can just use for teaching algorithmization not only in elementary school.

The tools themselves can be saved and uploaded for use in other GeoGebra files. Everything is done through the Tools menu item, where we select Manage Tools. The next step is to select the tool you have created from the menu and click on Save As, which will save the tool itself to its own file with the file extension ggt. Uploading the tool is then done via the basic menu item File and Open, where we upload the file with the tool itself and it will automatically appear in the toolbar. The other option is to drag the tool file (but it must have a ggt file extension) into a new GeoGebra window that is open.

With regard to the Framework Curriculum for Primary Education, it is not possible to define exactly in which grade the Thalet circle, the circles inscribed and circumscribed by a triangle, the altitudes and medians of a triangle are taught, as the curriculum divides only into grades I and II. However, if we look at the textbooks (Pomykalová, 2000), we expect to see the Thalet circle taught in Grade 8 (but in, for example, the textbooks for multi-year high schools, we encounter it as early as Grade 7). As for the properties of triangles, i.e. circles inscribed, inscribed, heights, and lines of gravity, these appear by default in Year 6 or 7 of primary school.

Then we will present the individual suitable tasks that we have already mentioned and their conversion into an algorithm by creating Custom tools in GeoGebra. Each sample problem will include a picture of the construction, the construction procedure and a description of the input and output for the algorithm and the input and output for the construction, respectively.

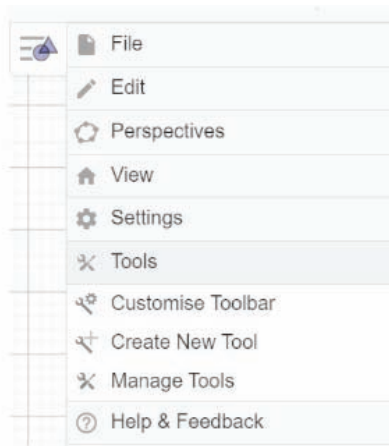


Figure 2. GeoGebra menu

In his thesis (Bukovský, 2023), Bukovský created the following tools that are suitable for teaching algorithms:

Thalet circle:

Input objects: line AB; Output Object: circle k,

Another tool is the well-known concept of the Thalet circle in geometry. This is a circle from which we can see a line segment at right angles. The diameter of this circle is always equal to the length of the line segment to which it is drawn.

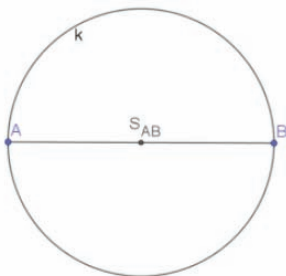


Figure 3. Thalet circle

It should be noted that this is a circle without two points that are also the extreme points of the line segment, because they do not satisfy the required property about right angles. The construction itself is very simple and allows the student to identify the steps. So the student first constructs the line segment AB. Then he/she constructs the centre of this line segment S_{AB} . The last step is to construct the circle k, which is given by the center and the point. The centre

of the circle k is located at the point S_{AB} and the point determining its radius is one of the extreme points of the line segment AB . And thus has constructed a simple algorithm.

The circles inscribed of triangle

Input objects: triangle ABC ; Output objects: circle k

This is the circle that touches all sides of the triangle and its centre is at the intersection of the axes of the interior angles of the triangle. So we start by creating an arbitrary triangle and creating the axes of its interior angles, see the tool of the same name. Let us denote the intersection of these axes as point S . It remains to determine the radius of this circle by finding the nearest possible point from point S located on one of the sides of the triangle. We then construct a line i which is perpendicular to either side of the triangle and also passes through point S . At the intersection of line i with one of the sides we form a point E . We are then able to construct a circle k given by the center of S and the point E , which is our search circle inscribed in the triangle.

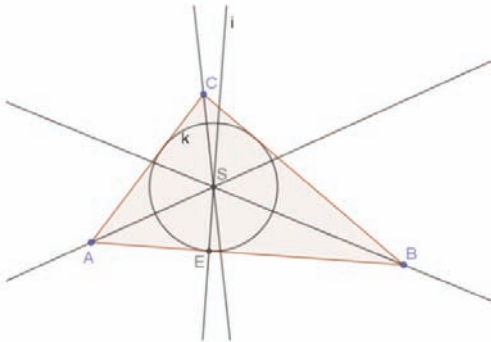


Figure 4. The circle inscribed of triangle

The circle circumscribed by a triangle

Input objects: triangle ABC ; Output objects: circle k

The circumscribed circle passes through all vertices of the triangle and its centre lies at the intersection of the axes of its sides. The radius of this circle is therefore the distance from the centre of the circle to any vertex of the triangle. As with the construction of the inscribed circle tool, we begin by constructing an arbitrary triangle ABC . Using the line segment tool, we construct the axis of each side of it. The intersection of these axes is called point S . Now all we have to do is construct the inscribed circle itself. So we create a circle k centered at S given any vertex of triangle ABC .

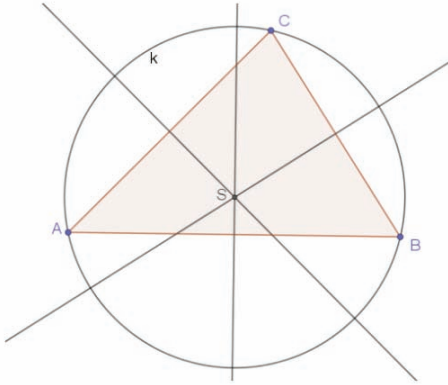


Figure 5. The circle circumscribed by a triangle

Conclusion

The aim of the paper was to point out other possibilities of teaching algorithms and their integration into mathematics teaching or elective subjects. This is a pilot phase where suitable tasks have been identified and future plans are to test selected tasks in the classroom by experienced teachers working with our department. It is also good to note that the Creation Toolkit is not only a useful tool in teaching algorithmization, but it is mainly a very powerful tool that allows teachers to create more effective materials. In particular, using dynamic geometry is not a problem when creating any design problem of a similar type. Since the teacher only needs to create the task and then simply modify the input parameters of the design task. The following steps help him to speed up the solution of these problems, since the teacher is an expert in the given problem and no longer needs to repeat the basic design principles of the set of points of the given properties. For example, the creation of the thalet circle tool need not be the final product, but can be used to solve construction problems where the tuple to the circle needs to be created from an external point.

Ethics Statement

The ethics committee confirmed to the corresponding author that this research did not require ethics approval because of the full anonymization of the publicly available data and because the data are not sensitive.

Conflicts of Interest

The authors declare no conflict of interest.

References

- Národní pedagogický institut, Digitální kompetence, (2021). Dostupné <https://archiv-nuv.npi.cz/p-kap/rozvoj-ict-kompetenci.html>
- Bukovský, M. (2023) GeoGebra Nástroje ve výuce geometrie. Diplomová práce Ostravská univerzita 2023.
- Knuth, D. E.(2008) Umění programování. Přeložil David KRÁSENSKÝ. Brno: Computer Press, 1. díl, Základní algoritmy.
- Javorčík, T., Kostolanyová, K.,Havlásková, T. (2023) Microlearning in the Education of Future Teachers: Monitoring and Evaluating Students' Activity in a Microlearning Course. EJEL, pp 12-25. <https://academic-publishing.org/index.php/ejel/article/view/2623/2112>
- Národní pedagogický institut, RVP v oblasti informatiky a ICT, (2018). Dostupné <https://archiv-nuv.npi.cz/t/revize-rvp-ict.html>
- NCTM. Nationals council of Teachers of Mathematics. (2000) Principles and standards for school mathematics [online] . Reston, VA: Author, 2000. ISBN 0-87353-480- 8 [cit. 2023-03-16]. Dostupné z https://www.rainierchristian.org/NCTM_principles-and-standards-for-school-mathematics.pdf
- Polasek, R. & Javorcik, T. (2019). MicroLearning approach to e-learning course creation and reasons for it. AIP Conference Proceedings. 2186. 060015. 10.1063/1.5137969. https://www.researchgate.net/publication/337883133_MicroLearning_approach_to_e-learning_course_creation_and_reasons_for_it
- Vaníček, J. (2009) Počítačové kognitivní technologie ve výuce geometrie. Praha: Univerzita Karlova v Praze, Pedagogická fakulta. ISBN 978-80-7290-394-8.
- Žáček, M. a Smolka, P. (2019) Development of computational thinking: Student motivation using ozobot. In: 3rd International Conference on Education and E-Learning: ICEEL 2019 2019-11-07 Barcelona. Barcelona: Association for Computing Machinery. s. 36-40. ISBN 978-145037225-1.

Věra Ferdiánová¹, Jakub Poruba², Marek Bukovský³

¹ *Department of Mathematics, Faculty of Science, University of Ostrava*

² *Department of Information and Communication Technologies, Faculty of Education, University of Ostrava*

³ *ZŠ a MŠ Veřovice, p.o., Veřovice 276, 742 73 Veřovice*

vera.ferdianova@osu.cz

Student's knowledge regarding air pollution and the role of multimedia in changing attitudes

Agnieszka Lewandowska, Małgorzata Nodzyńska-Moroń

[DOI 10.24917/9788368020403.2](https://doi.org/10.24917/9788368020403.2)

Abstract

Air pollution is one of the most important and serious environmental problems affecting both Poland and the entire world. People's knowledge about this issue is insufficient, hence the idea of expanding it through multimedia e-book. The aim of this study is to investigate the awareness of Polish university students regarding air pollution and to assess whether the created multimedia e-book influences the enhancement of their existing knowledge and change in their approach to this subject. Two surveys were conducted — before and after acquainting the participants with the multimedia e-book. The results of the pretest indicated that students have an inadequate level of knowledge about air pollution, and furthermore, only a few of them take action to address this problem. The created multimedia e-book deepened the knowledge of the majority of students regarding air pollution, after acquainting with e-book, students achieved higher results in the posttest survey compared to the pretest survey. The evaluation results of the e-book indicated a positive reception by the respondents.

Keywords

air pollution, environmental awareness, multimedia, interactivity, e-book

The context and purpose of the framework

Human activities have a detrimental impact on the environment through the contamination of the water we consume, the air we breathe and the soil supporting plant growth. Air pollution constitutes a complex mixture of molecules of gases, liquids and solids. Common atmospheric pollutants include carbon monoxide (CO), sulfur dioxide (SO₂), nitrogen oxides (NO_x), ozone (O₃) and particulate matter PM_{2,5} and PM₁₀. Air pollution represents one of the most significant environmental issues, not solely due to its contribution to climate change but also because of its adverse consequences for human health, leading to an increase in diseases and fatalities. With the progressive development of industries and the growing number of motor vehicles, the emission of harmful substances into the atmosphere continues to rise. Despite the variety of natural physical processes

(volcanic eruptions, wildfires, etc.) that can release various pollutants into the environment, anthropogenic activities remain the primary source of air pollution.

One of the factors that affect the reduction of air pollution is a change in society's behavior, which necessitates continuous education and effective communication. It appears that awareness regarding air pollution should have increased in recent years. This growth can be attributed to scientific research, reports, media coverage, non-governmental organization campaigns, social movements, governmental initiatives, as well as the increasing ecological awareness and emphasis on sustainable development. Nevertheless, despite air pollution being a pervasive issue, social knowledge and awareness about it remain inadequate. Among students, who are represent future leaders and decision-makers, there often exists a lack of awareness regarding the impact of air pollution on their health and the natural environment. Therefore, it is essential to identify effective educational methods capable of increasing knowledge and altering students' approach to this significant environmental issue. Multimedia serves as a prime example, as it facilitates knowledge absorption through visualization and graphical presentation, interactivity, access to diverse content, connecting content to real-life contexts, global accessibility, and enabling knowledge sharing.

The conducted research aims to investigate the awareness of Polish university students regarding air pollution and determine whether the created multimedia e-book increases their current knowledge and changes their approach to this topic. This study also seeks to broaden the understanding of the impact of multimedia on improving awareness of air pollution. The tools utilized in this study were two survey questionnaires (pretest and posttest surveys) conducted before and after participants engaged with the multimedia e-book. It is anticipated that the use of interactive educational tools, such as the multimedia e-book, can effectively increase students' awareness and engagement in air quality protection.

Based on available data in the scientific literature, the following hypotheses have been formulated:

1. Polish university students possess a low level of awareness regarding air pollution.
2. The created multimedia e-book improves the students' knowledge of air pollution and changes their approach to this topic.
3. After familiarizing with the multimedia e-book, students will get higher results in the posttest survey compared to the pretest survey.

Literature Review

Research on public awareness and societal understanding of air quality yields mixed results. Some studies confirm significant public concern about poor air quality, with respondents being aware of air quality alerts, and a positive relationship between alerts and changes in outdoor activities. In contrast, other studies confirm that both awareness of the link between air pollution and poor health and understanding of air quality information are insufficient among the public. Additional studies highlight limited knowledge about the causes and sources of air pollution. Some research also notes that certain sociodemographic factors influence how people perceive air quality. It has been found that young and elderly individuals, women, urban residents, individuals with higher education, those with health issues, and their caregivers are more aware of air quality problems and understand their consequences. Lack of interest in the topic may exist among healthy individuals who have fewer personal experiences with the benefits of pollution reduction.

Methods

The method chosen in this study was a diagnostic survey, the technique — a questionnaire, and the tools — two surveys. Self-created surveys were conducted before and after the participants were familiarized with the multimedia e-book, using the Google Forms online questionnaire platform. The surveys were made accessible to Polish university students, either online or in person, during the period from February to May 2023. The pretest survey aimed to gather basic information about the respondents (7 questions) and assess their knowledge of air pollution in Poland and globally (13 questions). In the posttest survey, the increase in knowledge was checked, and the students also evaluated the e-book. The posttest survey was divided into 2 sections. The initial section required participants to provide a nickname and indicate whether they had engaged with the e-book. A negative response prevented access to the second section, which comprised evaluative questions about the e-book (11 questions) and questions that mirrored those presented in the pretest, assessing students' awareness of air pollution.

The self-designed multimedia e-book, titled “Air pollution in Poland and in the world” incorporates information related to the subject of air pollution, along with answers to the questions posed in the survey. This information is presented, using a various multimedia elements, including: infographics, videos, attachments, games, and tests. The e-book was developed utilizing the Book Creator tool and encompasses a total of 16 infographics, 11 videos, 2 PDF documents, and 6 interactive games. The link to access the e-book was distributed to research participants via email, along with a link to the posttest survey (https://read.bookcreator.com/nWI81WiY2RdwvEuvHX0eQ7T4lx11/ntlg_3XpSJG19znkKCgo5Q).

Results

In the pretest survey participated a total of 167 individuals, 125 females (74.9%) and 42 males (25.1%). More than half of the respondents (50.9%) were students at the Pedagogical University of Cracow (85 individuals). The majority of the surveyed individuals (55.7%) resided in single-family homes (93 individuals). The most popular heating method in the respondent's homes was the use of municipal heating networks, as indicated by 63 respondents (37.7%). The second most frequently mentioned source was gas heating, owned by 52 individuals (31.1%). Coal stoves ranked as the third most popular heating source, declared by 36 study participants (21.6%). Other alternative heating methods, such as heat pumps (5 individuals - 3.0%), "photovoltaics, heat pump, emergency gas stove" (1 individual - 0.6%), fireplace (2 individuals - 1.2%), "heating fireplace and wood-burning stove" (1 individual - 0.6%), wood-burning stove (1 individual - 0.6%), eco-coal (2 individuals - 1.2%), pellet (1 individual - 0.6%) electric heating (1 individual - 0.6%), were less commonly found in the family homes of the surveyed students. Additionally, some responses suggested a lack of awareness in this area, such as "I don't know" (1 individual - 0.6%) and "with wood" (1 individual - 0.6%).

In the pretest survey participated a total of 167 individuals, but only 44 individuals completed the posttest survey, despite sending an email with the posttest survey twice and requests from some lecturers. One person did not familiarize themselves with the multimedia e-book, and therefore did not have access to the second section of the posttest survey. Consequently, 43 individuals provided answers to the evaluative questions regarding the e-book and the questions assessing student's awareness of air pollution. It is worth noting that reduced response rate among participants may be attributed to various factors, including fatigue or lack of time and interest in the research topic. Typically, survey return rates are low, with only about 20% being returned. In the case of this study, 26% of surveys were returned. Comparing responses in both surveys using participant nicknames was possible for 40 individuals. Given the small sample size in the posttest survey, discussing percentage values may not be entirely accurate or reliable, yet it is necessary in order to compare pretest survey results with posttest survey results.

The pretest results showed that students have an insufficient level of knowledge about air pollution. The created multimedia e-book deepened the knowledge of most students on this subject, following their engagement with it, students achieved higher results in the posttest survey compared to the pretest survey.

One of the questions in the surveys was: "Do you consider air pollution to be a real threat?". In the posttest survey, the percentage of individuals considering air pollution a real threat increased from 75.4% (126 individuals) to 79.1% (34 individuals), while the percentage of people who perceived air pollution as a less serious threat decreased from 22.2% (37 individuals) to 20.9% (9 individuals).

The above-mentioned data is presented in Figure 1. The bars contain numerical values in parentheses indicating the number of respondents for each response, and error bars with a percentage value (10.0%).

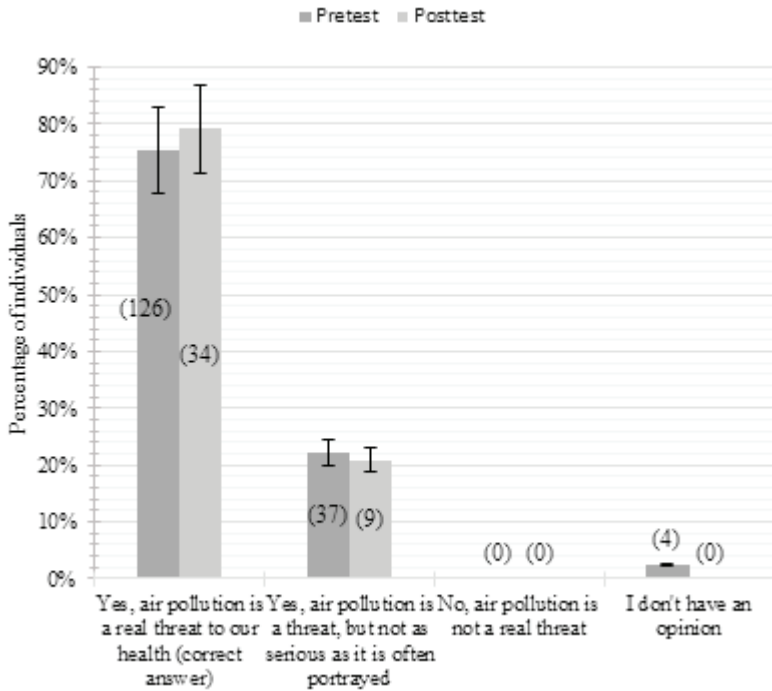


Figure 1. Do you consider air pollution to be a real threat?

The analysis of responses to the question about commonly occurring air pollutants revealed some differences between the pretest and posttest surveys (Figure 2). In the posttest survey, the responses from participants indicated a greater awareness of common air pollutants. A total of 20 respondents provided completely correct answers, even though they did not provide a correct answer in the pretest survey. The percentages of individuals providing correct answers were as follows: 81.4% (35 individuals) for PM_{2,5} and PM₁₀ particulate matter, 67.4% (29 individuals) for sulfur dioxide SO₂, 67.4% (29 individuals) for carbon monoxide CO, and 76.7% (33 individuals) for nitrogen dioxide NO₂. In the case of carbon dioxide CO₂ and methane CH₄, the percentages of individuals providing incorrect answers were lower than in the pretest survey (30.2% — 13 individuals - and 18.6% — 8 individuals, respectively).

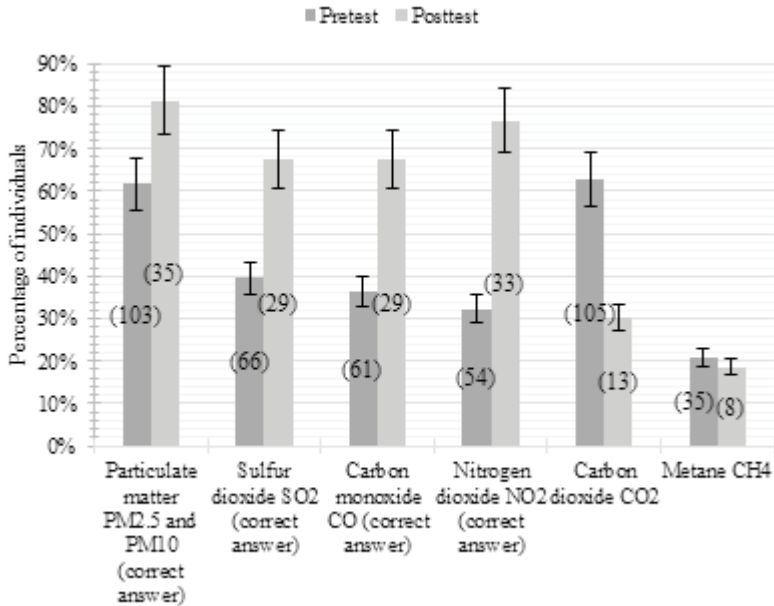


Figure 2. What are common air pollutants?

The correct answer to the question “According to the “2021 World Air Quality Report” by IQAir, the most polluted country in the world in terms of PM_{2.5} particulate matter was...” was Bangladesh. In the posttest survey, the answer “Bangladesh” was chosen by 88.4% of the respondents (38 individuals), while in the pretest survey, this percentage was 16.8% (28 individuals) (Figure 3). 27 respondents changed their answer to the correct one in the posttest survey.

The second section of the posttest survey began with 11 evaluative questions regarding the multimedia e-book, which were completed by 43 individuals, because one person did not engage with the material and thus did not have access to the second section.

In response to the question, “Do you like the way you learn using the multimedia e-book?” 65.1% of the respondents (28 individuals) answered “yes”, 25.6% (11 individuals) answered “rather yes”, 2.3% (1 person) answered “rather no”, and 7.0% (3 individuals) answered “no” (Figure 4). In the figures below, numerical values indicating the number of individuals who provided each response are shown in parentheses.

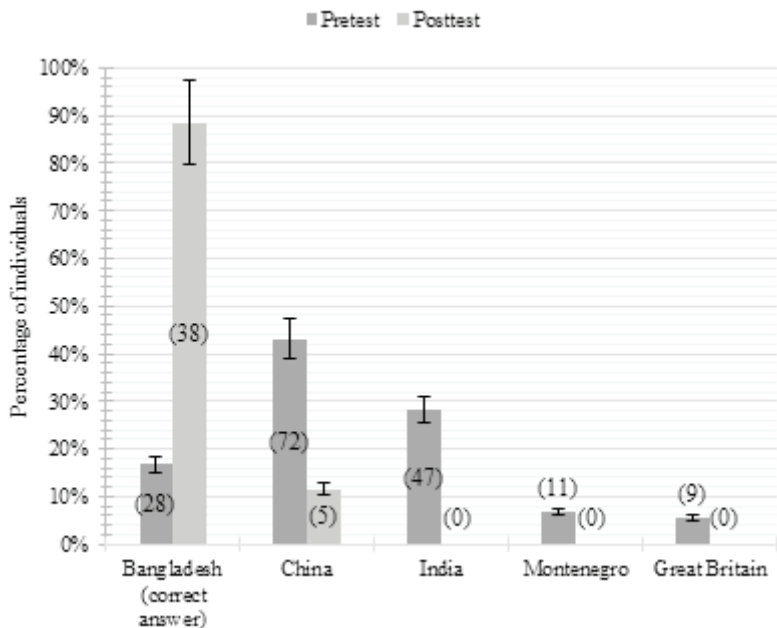


Figure 3. According to the “2021 World Air Quality Report” by IQAir, the most polluted country in the world in terms of PM_{2,5} particulate matter was...

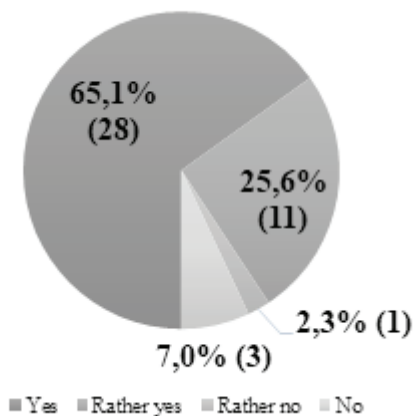


Figure 4. Do you like the way you learn using the multimedia e-book?

In response to the question, “Is this way of acquiring knowledge understandable to you?” 79.1% of respondents (34 individuals) answered that such a way is understandable to them, 18.6% (8 individuals) answered “rather yes”, and 2.3% (1 person) answered “rather no” (Figure 5). Despite the positive responses, it is noteworthy that one respondent indicated that the way of acquiring knowledge through the multimedia e-book is rather not understandable. For some individuals, excess of multimedia elements may cause confusion and make it hinder concentrate.

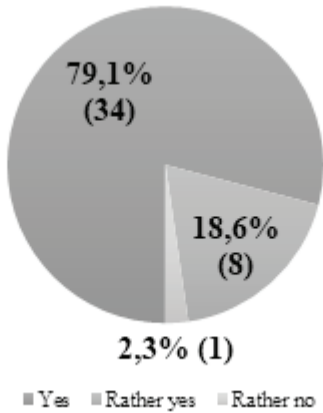


Figure 5. Is this way of acquiring knowledge understandable to you?

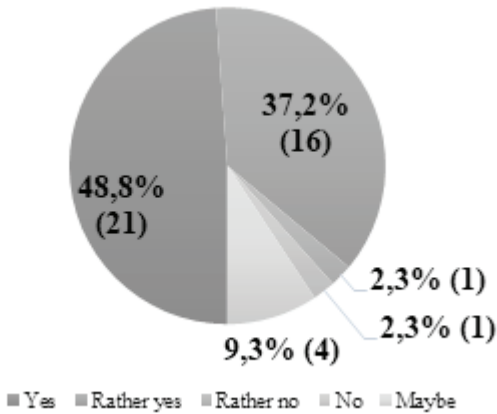


Figure 6. Would you recommend this e-book to others?

In response to the question, “Would you recommend this e-book to others?” 48.8% of respondents (21 individuals) answered that they would recommend the e-book to others, 37.2% (16 individuals) responded “rather yes”, 2.3% (1 person) answered “rather no”, 2.3% (1 person) answered “no” and 9.3% (4 individuals) answered “maybe” (Figure 6). Most respondents expressed a willingness to recommend the e-book to others, indicating a positive evaluation and interest in the content presented in the material.

Conclusions and implications

Non-communicable diseases are the leading cause of death worldwide. Air pollution is the second-largest environmental risk factor associated with non-communicable diseases, following tobacco use. The issue of air pollution is relevant and significant both at the national and global levels. It is worth noting that this work on air pollution contributes to the field of education by utilizing a multimedia e-book as a tool for teaching and learning.

There are various publications examining people’s awareness of air pollution, but there are few of them, and none of them investigate the impact of multimedia on knowledge growth in this specific area. In one study, it was found that 51% of respondents in different age groups were able to identify at least one substance causing air pollution. The most common answers were carbon monoxide and carbon dioxide, even though carbon dioxide is primarily related to climate change. In the case of this research, in the pretest survey, the most frequently marked answer for common air pollutants was carbon dioxide (62.9%) and particulate matter PM_{2,5} and PM₁₀ (61.7%).

In light of the conducted research and the analysis of collected data, it can be concluded that all the formulated objectives of the study have been achieved, and the stated hypotheses have been proven. The pretest results indicated that students had an insufficient level of knowledge about air pollution, and furthermore, only a few of them were taking measures to address this issue. This highlights the need for further knowledge development in this area and the importance of educational efforts among students. Conversely, the posttest results suggested that the multimedia e-book contributed to an increase in the participants’ knowledge about air pollution. The noticeable increase in knowledge among the majority of study participants demonstrates the effectiveness of the e-book in conveying information. It was observed that many of the respondents were intrigued by the topic and engaged in the research. It is also worth emphasizing that there was a certain percentage of respondents who did not show significant knowledge growth. This may be due to various factors, such as the initial knowledge level of the responders, individual differences in information assimilation, or the need for further in-depth exploration of the topics. Therefore, continuous improvement of the e-book by considering different knowledge levels and tailoring content

to the needs of various audience groups is crucial. Additionally, the e-book evaluation results indicated a positive reception by the respondents. Most of them would recommend it to others. Analyzing the results regarding the assessment of individual elements of the e-book, it can be concluded that the text, graphics, videos, and games were generally rated at highly, with a small percentage of respondents expressing dissatisfaction.

Publications also confirm the effectiveness of using multimedia in the learning process. Through the use of multimedia techniques, students are more willing to participate in classes that pique their greater interest. The incorporation of visual, sound and interactive elements not only makes the classes more engaging, but also accelerates the process of acquiring knowledge, which is more likely to be retained during the classes.

There are also a few studies related to the Book Creator tool, but the e-books created in these studies cover different topics other than air pollution. The results of two publications demonstrated that the Book Creator application was effective in enhancing English language skills among students. Other research findings also illustrate the effectiveness of Book Creator as an educational tool aimed at enhancing students' language competencies.

The results of the present study serve as a starting point for further research on e-books as educational tools and can contribute to the development of innovative teaching and learning methods. It is advisable to continue research to further assess the effectiveness and impact of multimedia on the learning process. Future studies could focus on expanding the research sample to include different age groups and levels of education, as well as comparing the effectiveness of e-books with other educational methods, such as traditional textbooks or teacher-led classes. Additionally, it would be worthwhile to examine the long-term effect of the e-book on knowledge acquisition and interest in the researched topics, for example, by surveying participants some time after completing their use of the e-book. Comparing these methods can provide valuable insight into the effectiveness of different educational tools and highlight the best approaches to environmental education. Such analyses will lead to a better understanding of the potential of multimedia e-books and provide a solid foundation for the further development of this innovative tool in the field of education.

Ethics Statement

The ethics committee confirmed to the corresponding author that this research did not require ethics approval because of the full anonymization of the publicly available data and because the data are not sensitive.

Conflicts of Interest

The authors declare no conflict of interest.

References

- Al-Khamees, N. A., & Alamari, H. (2009). Knowledge of, and attitudes to, indoor air pollution in Kuwaiti students, teachers and university faculty. *College Student Journal*, 43(4), 1306-1312.
- Al-Khamees, N. A. (2018). Knowledge of, Attitudes toward, and Practices regarding Indoor Pollution at Kuwait University. *Journal of Geoscience and Environment Protection*, 6(12), 146-157. <https://doi.org/10.4236/gep.2018.612011>
- Ciążela, A. (2018). Wiedza polskich studentów o środowisku naturalnym i jego ochronie - porównanie studentów różnych kierunków i uczelni. *Zeszyty Naukowe. Organizacja i Zarządzanie*, 123, 73–88. <https://doi.org/10.29119/1641-3466.2018.123.6>
- Darmayanti, R., Baiduri, B., & Sugianto, R. (2022). Learning Application Derivative Algebraic Functions: Ethnomathematical Studies and Digital Creator Books. *Jurnal Cendekia: Jurnal Pendidikan Matematika*, 6(2), 2212–2227. <https://doi.org/10.31004/cendekia.v6i2.1445>
- IQAir (2022). 2021 World Air Quality Report. Region & City PM2.5 Ranking. <https://www.iqair.com/world-most-polluted-cities/world-air-quality-report-2021-en.pdf>
- Kampa, M., & Castanas, E. (2007). Human health effects of air pollution. *Environmental Pollution*, 151(2), 362–367. <https://doi.org/10.1016/j.envpol.2007.06.012>
- Kelly, F. J., & Fussell, J. C. (2015). Air pollution and public health: emerging hazards and improved understanding of risk, *Environmental Geochemistry and Health*, 37(4), 631–649. <https://doi.org/10.1007/s10653-015-9720-1>
- Krakowski Alarm Smogowy, & Fundacja EkoUnia. (2015). Co wiemy o smogu? Raport z badania dostępu do informacji o zanieczyszczeniu powietrza. Krakowski Alarm Smogowy.
- Lenik K., & Gawrylak, B. (2007). Dobór form prezentacji multimedialnych w dydaktyce szkoły wyższej na przykładzie problematyki dystrybucji wyrobów. *Postępy Nauki i Techniki*, 1, 101–110.
- Maharani, A. A. P., & Santosa M. H. (2021). The Implementation of Process Approach Combined with Screencast-O-Matic and Bookcreator to Improve Students' Argumentative Writing. *LLT Journal: A Journal on Language and Language Teaching*, 24(1), 12–22. <https://doi.org/10.24071/llt.v24i1.2516>
- Maione, M., Mocca, E., Eisfeld, K. Kazepov, Y., & Fuzzi, S. (2021). Public perception of air pollution sources across Europe. *Ambio*, 50, 1150–1158. <https://doi.org/10.1007/s13280-020-01450-5>

- Mokwa-Tarnowska, I., Kołodziejczak, B., & Roszak, M. (2018). Od zajęć wspomaganych narzędziami internetowymi do kursów online – Efektywność nowych środowisk uczenia się w opiniach studentów. *Zeszyty Naukowe Wydziału Elektrotechniki i Automatyki Politechniki Gdańskiej*, 58, 57–62.
- Nishida, C., & Yatera, K. (2022). The Impact of Ambient Environmental and Occupational Pollution on Respiratory Diseases. *International Journal of Environmental Research and Public Health*, 19(5), Article 2788. <https://doi.org/10.3390/ijerph19052788>
- Schmitz, S., Weiland L., Becker, S., Niehoff, N., Schwartzbach, F., & Schneidemesser E. (2018). An assessment of perceptions of air quality surrounding the implementation of a traffic-reduction measure in a local urban environment. *Sustainable Cities and Society*, 41, 525–537. <https://doi.org/10.1016/j.scs.2018.06.011>
- Shaddick, G., Thomas, M. L., Mudu, P., Ruggeri, G., & Gumy, S. (2020). Half the world's population are exposed to increasing air pollution. *npj Climate and Atmospheric Science*, 3(1), Article 23. <https://doi.org/10.1038/s41612-020-0124-2>
- Smallbone, K. (2012). Individuals' interpretation of air quality information: Customer insight and awareness study. Department for Environment Food & Rural Affairs. http://uk-air.defra.gov.uk/assets/documents/reports/cat14/1210261047_Individuals_interpretation_of_air_quality_information_customer_insight_&_awareness_study.pdf
- Spaliviero, C. (2022). Pre-Service Primary Teachers' Beliefs, Practices, and Needs Regarding the Teaching of a Second Language Through Book Creator. *International Journal of Linguistics*, 14(5), 34–64.
- Targońska, J. (2009). Czy sama obserwacja lub sam sondaż diagnostyczny są w pełni obiektywnymi metodami badawczymi? Kilka uwag na temat metodologii badań pedeutologicznych. In M. Pawlak, M. Mystkowska-Wiertelak, A. Pietrzykowska (Eds.), *NAUCZYCIEL JĘZYKÓW OBCYCH DZIŚ I JUTRO* (pp. 437–449). Wydział Pedagogiczno-Artystyczny UAM w Kaliszu, Uniwersytet im. Adama Mickiewicza w Poznaniu.
- Yik, L. J. (2022). Improving Year 6 Pupils' Interest And Ability In English Essay Writing Through Book Creator. W: R. E. Capel & Q. S. Hoon (Eds.), *CONFERENCE PROCEEDINGS. iELT-CON 2021. 10th International English Language Teaching Conference. Developing Future Skills in English Language Teaching, Virtual Conference*, 11–26.

Agnieszka Lewandowska, Małgorzata Nodzyńska-Moroń

Department of Politcs and Social Research, Institute of Journalism and International Relations, Pedagogical University of Cracowaga.

lewandowskaa@gmail.com, malgorzata.nodzynska-moron@up.krakow.pl

Artificial intelligence in the teacher's work

Małgorzata Nodzyńska-Moroń

[DOI 10.24917/9788368020403.3](https://doi.org/10.24917/9788368020403.3)

Abstract

Artificial intelligence has many applications in the field of education and can bring many benefits to students and teachers. Thanks to AI, it is possible to personalize teaching - you can create personalized learning environments tailored to the individual needs and learning style of students. AI systems can analyze data and deliver personalized content, assignments, and grades. Smart tutorials can be created. AI systems can identify areas of student difficulty, deliver interactive learning materials, and offer customized exercises to help students understand the material better. AI can automate the process of grading papers and tests. Using natural language analysis and machine learning techniques, AI systems can evaluate student responses, providing quick and objective feedback. AI can provide individual support to students, regardless of their location. Through online technologies and AI systems, students can access learning resources, tutoring, and support materials that are tailored to their needs. AI can help analyze large amounts of data, such as test scores, student behavior, and demographics. Educators can use this information to identify trends, adjust curriculum, and make data-driven decisions. AI can provide teachers with tools and data that help them make decisions about curriculum, choice of educational materials or teaching strategies.

The article discusses examples of specific solutions for the use of AI by the teacher in chemistry lessons.

Keywords

Artificial intelligence, education, teacher

Introduction

Artificial intelligence has many applications in the field of education and can bring many benefits to students and teachers. Thanks to AI, it is possible to personalize teaching - you can create personalized learning environments tailored to the individual needs and learning styles of students. AI systems can analyze data and deliver personalized content, assignments, and grades. Smart

tutorials can be created. AI systems can identify areas of student difficulty, deliver interactive learning materials, and offer customized exercises to help students understand the material better. AI can automate the process of grading papers and tests. Using natural language analysis and machine learning techniques, AI systems can evaluate student responses, providing quick and objective feedback. AI can provide individual support to students, regardless of their location. Through online technologies and AI systems, students can access learning resources, tutoring, and support materials that are tailored to their needs. AI can help analyze large amounts of data, such as test scores, student behavior, and demographics. Educators can use this information to identify trends, adjust curriculum, and make data-driven decisions. AI can provide teachers with tools and data that help them make decisions about curriculum, choice of educational materials or teaching strategies.

Research Problems

Preparing the teacher for the lesson is a key element of effective education. When preparing, the teacher should not only know the content well but also think about the form of its transmission. It is important to correctly define the objectives of the lesson, prepare teaching materials, plan the structure of the lesson, choose the teaching method, and plan the assessment of students' progress. It is also important to match the selected methods to specific students. It was decided to investigate whether it is possible to use artificial intelligence for this work.

Research Methodology

It was decided to check whether it is possible to use artificial intelligence to create an anti-topic, provide lesson objectives (according to Bloom and Niemierka's taxonomy), describe student success criteria, write a lesson outline (traditional, constructivist and drama), provide activating methods for lessons (chemical experiments, simulations, applications on the phone), creating a test with 10 different tasks based on Bloom's taxonomy and adapting this test for the weaker and more able student, and assessing the student's work using formative assessment. The correctness of the tasks performed was evaluated using a 3-point graphical scale:



Figure 1. The graphical scale used in the research

Research Results

Lesson topic

The lesson's topic should be engaging and interesting for students, it should cause the so-called WOW effect. According to neuro-didactics (Kaczmarzyk, 2018), the teacher has only about 5 minutes to interest the students in the topic of the lesson. Therefore, one of the most interesting techniques is using the anti-theme. Since many teachers have a problem with creating an interesting counter-topic, it was decided to check the possibility of using the ChatGPT for this task.

Table 1. Recording of a ChatGPT conversation about the anti-topic

MnM	ChatGPT
Create an anti-theme to the lesson on "Oxygen and its properties".	"Lack of oxygen - a disaster for living organisms"
You don't understand the definition of anti-theme. The anti-theme consists in reversing the problem and searching in accordance with the newly formulated problem. We use this method when the answers to the first question are stereotypical. For example, it is difficult to find revealing answers to the question: Why should we protect the environment? However, when we turn the problem around and ask: why should we not protect the environment? - it is the first question that we look at in a new way, and the answers are no longer trivial.	Sorry for the imprecise understanding of the definition of anti-theme. Thanks for the clarification. Below is an inverted problem for the lesson "Oxygen and its properties" - anti-theme: "Oxygen - excess as a potential threat"
It's still not anti-theme.	Sorry for the imprecise understanding of the definition of anti-theme. I am asking for your understanding. Here is an example of an anti-theme to the lesson "Oxygen and its properties": "Is oxygen really necessary for life?"

It seems that this time the anti-theme is given correctly - however, ChatGPT's further explanations - contradict it. "Oxygen is traditionally believed to be essential for most living organisms and life processes. However, turning the perspective around, we can ask the question, is it impossible to function without oxygen, or are there some unknown life forms that do not require oxygen to survive? By examining such an anti-theme, one can discuss alternative environments and organisms that have evolved in extreme conditions where oxygen is limited or completely absent. Examples are organisms that live in the ocean depths, in extreme deserts or in thermal ecosystems. By discussing this anti-theme, students can explore extremophiles, such as methanogenic bacteria that live in anaerobic conditions, or organisms that use substances other than oxygen, such as hydrogen sulfide and methane, for respiration. By reversing the traditional perspective and asking the question of the possibility of life without oxygen, curiosity can be aroused and students explore different adaptations and survival strategies in different environmental conditions."

As you can see, the teacher not only has to explain to the ChatGPT what the anti-theme is, but the final version of the anti-theme is not satisfactory. Rather, in this area ChatGPT will not replace the teacher.

Lesson objectives according to Bloom and Niemierko's taxonomy

Another tested element was the provision of lesson objectives via ChatGPT. Defining learning objectives is one of the most important elements of teacher preparation for the lesson (Jyż-Kuroś, & Nodzyńska, 2022). The ability to specify targets according to Bloom (1956) and Niemierko (2021), used in Poland, was checked.

Question for ChatGPT: Give Bloom's goals for the lesson on "Oxygen and its properties."

ChatGPT response: Examples of Bloom's goals that could be related to the lesson on "oxygen and its properties" in the context of different cognitive levels are:

Memory:

List at least three physical properties of oxygen.

Repeat the definition of oxygen as a chemical element.

Understanding:

Explain why oxygen is important to sustain combustion.

Discuss why oxygen is necessary for respiration.

Application in practice:

Explore the different uses of oxygen in everyday life and industry.

Use your knowledge of the properties of oxygen to explain why it is used in specific situations, such as oxygen therapy or the steelmaking process.

Analysis:

Compare and contrast the properties of oxygen with other gases in the air.

Identify the chemical reactions of oxygen with other elements based on your observations.

Creation:

Design a simple experiment or demonstration to show the effect of oxygen on combustion.

Submit your own ideas for new oxygen applications in the future.

Synthesis:

Develop an experiment or demonstration that illustrates the properties of oxygen.

Create a presentation or written report on the importance of oxygen to life on Earth.

Suggest innovative uses of oxygen in scientific or technological fields.

As we can see, the goals according to Bloom's taxonomy were given correctly. And did ChatGPT cope equally well with the goals according to the Polish educator - Niemierko?

Question for ChatGPT: Give Niemierki goals for the lesson on "oxygen and its properties".

ChatGPT Response: Sorry, but I am unable to identify what goals you meant by "German goals". I have no information on a specific person by the name of Niemierko in the context of education or celebrating achievements. Can you provide more information or explain what exactly you are looking for?

Question to ChatGPT: Niemierko is a Polish educator, he divides the goals into: knowledge, skills, use in typical situations, and use in new situations.

ChatGPT's response: Sorry for the earlier misunderstanding. Now I understand what teaching is all about. Niemierko is a Polish educator who proposed the division of goals into four categories: knowledge, skills, use in typical situations and use in new situations. Here are some example goals from each of these categories related to the lesson on "oxygen and its properties":

Memory:

Identify the basic properties of oxygen, such as colorlessness, odorlessness,

and chemical reactivity.

Understanding that oxygen is essential to sustain combustion and respiration.

Skills:

Conducting observations and experiments to confirm some properties of oxygen, such as its effect on combustion or respiration.

Formulate questions and draw conclusions based on observations and experiments related to oxygen.

Application in typical situations:

Explaining the uses of oxygen in various fields such as medicine, steel industry and automotive.

Recognize situations where oxygen is essential or used in daily life.

Application in new situations:

Identification and analysis of potential new oxygen applications in various fields, such as emerging technologies or innovative methods of using oxygen.

Design and create new oxygen-related experiments or demonstrations.

Although ChatGPT did not know the taxonomy of Niemierka, he coped with the task very well. Therefore, it can be concluded that ChatGPT fulfilled this task very well.

Student Success Criteria

Another important element of preparing the teacher for the lesson is giving students the criteria for success (Cieśla, Nodzyńska, & Paško, 2007). Success criteria are detailed guidelines that show how to reach the goal, i.e. what the student should be able to do, what will be assessed, and what should pay attention to. According to John Hatti (2015), presenting students with success criteria, i.e. what is expected of them, significantly improves their learning outcomes. On the scale specified in his research, the indicator is - 0.88. Therefore, it was decided to check whether ChatGPT can effectively replace the teacher.

Question for ChatGPT: Give the success criteria for a lesson about oxygen and its properties.

ChatGPT's response: Here are some examples of success criteria for a lesson on oxygen and its properties:

Understanding Basic Concepts:

Students should be able to explain what oxygen is, what its properties are, how it reacts with other substances, and what are the uses of oxygen in everyday life.

Identification and description of oxygen properties:

Students should be able to list and describe the various properties of oxygen, such as reactivity, sustaining combustion, participation in oxidation reactions, etc.

Explanation of the importance of oxygen for combustion:

Students should understand that oxygen is necessary for the combustion process and can explain why fire goes out in conditions where oxygen is limited.

Identify the reaction of oxygen with other substances:

Students should identify and describe the reactions of oxygen with metal, hydrogen, and other substances, and understand what products are formed in these reactions.

Conducting experiments and observations:

Students should be actively involved in conducting experiments and observations related to oxygen, as well as be able to interpret the results and conclusions of the experiments.

Answering questions and explaining concepts:

Students should be able to give specific and understandable answers to questions about oxygen and its properties, as well as explain related concepts.

Student involvement and activity:

Students should be active, participate in discussions, ask questions and show interest in the topic of oxygen and its properties.

As we can see ChatGPT coped with this task very well.

Lesson outline

Another important element of preparing for the lesson is writing an outline (Mastalerz, 2006; Nodzyńska, & Paśko, 2002; Paśko, Nodzyńska, & Tejchman, 2002). Since this is a time-consuming task, it was decided to investigate whether ChatGPT could replace us in this case as well. In the original version, it was recommended to write a lesson outline without specifying which outline is meant. As a result, the correct, traditional outline of the giving lesson was obtained. Therefore, the second question asked for a constructivist lesson plan.

Table 2. Lesson plans suggested by ChatGPT: Traditional and Constructivist.

<p>Write an outline for a 45-minute elementary school lesson on “Oxygen and its properties”</p>	<p>Write a constructivist elementary school lesson plan for 45 minutes on the topic “Oxygen and its properties”</p>
<p>Topic: Oxygen and its properties Level: Primary school Duration: 45 minutes</p>	<p>Topic: Oxygen and its properties Level: Primary school Duration: 45 minutes</p>
<p>I. Introduction (5 minutes) Welcoming students and introducing the topic of the lesson. A brief overview of the importance of oxygen in our daily lives.</p>	<p>I. Introduction (5 minutes) Welcoming students and introducing the topic of the lesson. Ask students, “What do you think oxygen is? How do you think it is used in our lives?”</p>
<p>II. What is oxygen? (10 minutes) Explanation that oxygen is a chemical element. Overview of the chemical symbol and atomic number of oxygen. Mention that oxygen is a gas found in the air</p>	<p>II. Explore the concept of oxygen (15 minutes) A. Examination of student knowledge: - Ask students to share what they know about oxygen. - Write their answers on the board or flipchart. B. Studying Your Observations: - Ask students to make brief observations in the classroom, outside, or in their surroundings for evidence of oxygen. - Allowing students to share their insights and experiences. C. Working together on definitions: - Using students’ knowledge and observations, together create a definition of oxygen as a chemical element.</p>

<p align="center">Write an outline for a 45-minute elementary school lesson on “Oxygen and its properties”</p>	<p align="center">Write a constructivist elementary school lesson plan for 45 minutes on the topic “Oxygen and its properties”</p>
<p>III. Properties of oxygen (15 minutes)</p> <p>A. Physical Properties of Oxygen:</p> <ul style="list-style-type: none"> - Explanation that oxygen is colorless and odorless. - Discuss that oxygen is necessary to sustain combustion. - Presentation of information that oxygen has a lower density than air. <p>B. Chemical Properties of Oxygen:</p> <ul style="list-style-type: none"> - Explanation that oxygen is chemically reactive. - Discussion of the reaction of oxygen with other elements such as carbon, hydrogen, and sulfur. - Presentation of the fact that oxygen is necessary for respiration. 	<p>III. Investigating the properties of oxygen (20 minutes)</p> <p>A. Group Physical Properties Test:</p> <ul style="list-style-type: none"> - Divide the class into groups and assign to each group one physical property of oxygen, such as colorless, odorless, or light. - Ask the groups to do research to find more information and examples about the assigned property. - Each group presents its results. <p>B. Individual Chemical Testing:</p> <ul style="list-style-type: none"> - Ask students to do their own research into the chemical properties of oxygen, such as reactions with other elements. - Allowing students to share their observations and results.
<p>IV. Application of oxygen (10 minutes)</p> <p>Presentation of various uses of oxygen in everyday life and industry, such as:</p> <ol style="list-style-type: none"> a) Oxygen therapy in medicine. b) Steelmaking. c) Rocket fuel. d) Oxidation of fuels in cars. 	<p>IV. Application of oxygen (10 minutes)</p> <p>To introduce students to the different uses of oxygen in everyday life and industry, such as:</p> <ol style="list-style-type: none"> a) Oxygen therapy in medicine. b) Steelmaking. c) Rocket fuel. d) Oxidation of fuels in cars. <p>Encourage students to share their observations and experiences with oxygen applications.</p>
<p>V. Experiment (5 minutes)</p> <p>Carrying out a simple experiment, such as burning a candle and then covering it with a glass bulb with oxygen to show the effect of oxygen on combustion.</p>	

Write an outline for a 45-minute elementary school lesson on “Oxygen and its properties”	Write a constructivist elementary school lesson plan for 45 minutes on the topic “Oxygen and its properties”
VI. Summary (5 minutes) A summary of the topics discussed and the most important information about oxygen. Ask students questions to check their understanding of the topic. Thanking students for participating in the lesson and encouraging them to explore the topic further.	V. Summary and reflection (5 minutes) Ask students to share what they have learned about oxygen and its properties. Ask students the question: “What else would you like to know?”
VII. Q&A (5 minutes) Allowing time for questions and answers related to the topic under discussion.	

ChatGPT not only wrote the traditional outline but also wrote a constructivist version. It seems, therefore, that if we formulate the question correctly, we will get the correct outline in the form we choose.

Non-traditional outline - drama

However, the obtained lesson plans were typical for science lessons. It was also tried whether ChatGPT is able to write a non-traditional outline - for drama. Drama is a method of teaching and upbringing that fosters the comprehensive development of students and prepares them to play social roles in a changing reality (Way, 1990). By referring to the individuality of each human being, it is conducive to the extraction and development of the most desirable features of human personality. It develops independence in thinking and creativity of both students and the teacher, develops the ability to establish a dialogue, as well as emotional activity, and allows you to independently come to knowledge. Drama is rarely used in science lessons (Nodzyńska, & Cieśla, 2015).

Question for ChatGPT: Write a chemistry lesson plan about oxygen using the drama method.

ChatGPT: Lesson Title: “The Oxygen Adventure: Dramatic Discoveries”

Duration: 60 minutes

Lesson Objectives:

Understanding the importance of oxygen and its properties in everyday life.

Expanding knowledge about processes in which oxygen plays a key role.

Learning by engaging in dramatic scenes to better understand and remember information.

Materials needed:

Posters or illustrations showing different aspects of oxygen.

Costumes and props for dramatic scenes.

Lesson plan and copies for students.

The course of the lesson:

I. Introduction (5 minutes):

Welcoming students and introducing the topic of the lesson.

Asking the question: “Why is oxygen important to our life?”.

II. Information presentation (10 minutes):

The teacher presents basic information about oxygen, its properties and importance in life.

Use of posters or illustrations to visually support the presentation.

III. Creating drama groups (5 minutes):

Divide students into small groups.

Assign each group a scenario that focuses on different aspects of oxygen.

IV. Preparation of dramatic scenes (15 minutes):

Each group works to prepare a short dramatic scene that illustrates the assigned oxygen theme.

Pupils can invent dialogues, use costumes and props.

V. Presentation of dramatic scenes (20 minutes):

Each group presents their stage in front of the whole band.

Students can also ask questions and interact with the performers.

VI. Summary and discussion (5 minutes):

The teacher conducts a short discussion, raising questions such as: “What conclusions can we draw from the presented scenes?”, “What are the most important aspects of oxygen that we remember?”.

Summarizing the main points of the lesson and highlighting the importance of oxygen in everyday life.

VII. Homework (5 minutes):

Assign students a small research project in which they collect information about other chemical elements and their role in life.

As we can see, ChatGPT has prepared a correct framework lesson plan using the drama method. However, for a teacher (especially of science subjects) this may not be enough. The teacher may not have an idea of the scenario of such a performance, so he may feel bad in the role of a person who is supposed to help students. Therefore, it was decided to check whether ChatGPT is able to create such scenarios.

Question for ChatGPT: Give an example of a scenario that students should prepare.

ChatGPT's response: Of course! Here is an example of role-play students could create about the role of oxygen in combustion:

Scene: "Oxygen in Action - Combustion"

Characters:

Disciple A: The Role of Fire

Student B: The role of fuel

Student C: Role of oxygen

Narrator: Tells the events

Apprentice A (fire): He jumps up and makes a sound: "Meet me, I am Fire! I love to burn things!"

Apprentice B (fuel): He enters the stage holding wood: "And I am Wood, the perfect fuel for you, Fire!"

Student C (Oxygen): He comes on stage waving his arms: "And I am Oxygen, without which you, Fire, would not be able to burn!"

Narrator: Tells how oxygen, fuel, and fire work together in the combustion process.

Narrator: "There is peace in the forest when suddenly Fire enters the scene!"

Apprentice A (fire): He goes over to the Wood and starts heating it.

Narrator: "Fire needs fuel to burn! And here is Wood, which is the perfect fuel for Fire."

Student B (fuel): Starts to crackle and the fuel starts to slowly heat up.

Narrator: "But something else is needed for the Fire to burn bright and strong!"

Apprentice C (Oxygen): Runs around the stage, bringing air (oxygen) to the Fire.

Disciple A (Fire): It begins to ignite and burn brighter.

Narrator: “Fire needs Oxygen, which Oxygen supplies! It’s a combustion reaction where Oxygen combines with Wood, releasing heat and light.”

The scene ends and the students are thanked for their performances.

Question for ChatGPT: Prepare another scenario for this lesson.

ChatGPT’s response: Here is an example of another role-play students could create about the role of oxygen in respiration:

Scene: “Adventure with Oxygen - Breathing”

Characters:

Student A: The role of man

Student B: The role of oxygen

Student C: The role of carbon dioxide

Narrator: Tells the events

Student A (human): He enters the stage gesticulating as if he is having difficulty breathing.

Student B (Oxygen): He enters the stage holding a banner that reads “Oxygen”.

Student C (Carbon Dioxide): He enters the stage holding a banner that reads “Carbon Dioxide”.

Narrator: Tells how oxygen and carbon dioxide affect the breathing process.

Narrator: “We meet our hero, a man who needs his breath!”

Student A (human): Simulates difficulty breathing.

Narrator: “Luckily, Oxygen shows up in time to help!”

Student B (Oxygen): Approaches a man holding a banner that reads “Oxygen”.

Narrator: “Oxygen is essential for the proper functioning of our lungs and supplies oxygen to the blood!”

Student B (oxygen): Shows how oxygen enters the lungs and blood.

Narrator: “But watch out, Carbon Dioxide is also important!”

Student C (Carbon Dioxide): Approaches a man holding a banner that reads “Carbon Dioxide.”

Narrator: “Carbon dioxide is a by-product of the respiration process that must be exhaled!”

Student C (Carbon Dioxide): Simulates how carbon dioxide is excreted by humans.

The scene ends and the students are thanked for their performances.

It seems that the scenarios of performances created by ChatGPT are correct and can be a good inspiration for both teachers and students.

Chemical experiments

It is known that chemical experiments are the basis of chemistry lessons (Burewicz, Jagodziński, & Wolski, 2008; Nodzyńska, 2005, 2018). Therefore, it was decided to check whether ChatGPT is able to suggest what experiments should be performed in the classroom.

Question for ChatGPT: What experiments can be done in a lesson on oxygen and its properties?

Table 3. Examples of chemistry experiments given by ChatGPT

ChatGPT's response	Discussion of the correctness of the experiment
Candle burning: Conduct an experiment where you place a lit candle in a vessel and cover it with a glass cup or jar. Watch the fire go out as it consumes the available oxygen inside the vessel. Discuss with students the importance of oxygen for combustion.	Typical, correct experiment.
Effect of oxygen on smoking: Conduct an experiment where you ignite a small amount of paper and then cover it with a jar. Add a small amount of oxygen to the jar by blowing through the straw. Students will see the flame become brighter and more intense as the extra oxygen supports the combustion process.	An experiment is difficult to carry out in the way described. The paper will burn right away, and once covered it will go out immediately, HOW to insert the oxygen tube into the jar is not described.
Reaction of oxygen with metal: Conduct an experiment where you place a piece of magnesium or other metal in the flame of a Bunsen burner. Watch the metal ignite and react with the oxygen in the air to create bright sparks and metal oxide. Discuss with students the reaction of metal with oxygen and the formation of oxides.	Typical experiment. Students need to know that there is oxygen in the air and it is responsible for combustion.

ChatGPT's response	Discussion of the correctness of the experiment
<p>Reaction of oxygen with hydrogen: Conduct an experiment where you dip a small amount of hydrogen into the water in a test tube and then add a small amount of oxygen to it. Students will see that once the reaction is initiated, the water begins to boil and drops of water form on the walls of the test tube. Discuss with students the reaction of hydrogen with oxygen and the formation of water.</p>	<p>Weird description - it's hard to "dip" gas in a liquid. After initiating the reaction of hydrogen with oxygen, you can hardly see the boiling of water - but an explosion</p>
<p>Oxygen test: Perform a simple oxygen test. Put hydrogen peroxide in a test tube and add a small amount of iron powder to it. Observe how the iron powder reacts with the oxygen in the water to form brown precipitates. Explain to students that iron reacts with oxygen to form iron oxide.</p>	<p>The experiments may be correct but too complicated. The student needs to know that the decomposition of hydrogen peroxide produces oxygen and what is the result of the reaction of iron with oxygen.</p>

The proposed experiments are not described in detail. They are also not adapted to the given lesson and the level of students.

Activation methods

Learning by doing is more effective than the traditional, hands-on learning method. Therefore, activating methods are becoming more and more popular in education. They develop creative and critical thinking, broaden interests, develop the ability to communicate in a group, argue and draw conclusions. Matching the activating methods to the lesson to the lesson can be difficult for the teacher. Also, teachers often fall into a routine and choose the same activating methods for each lesson, regardless of its topic, which can be boring for students. Therefore, it was decided to investigate whether ChatGPT can replace the teacher in this activity.

Question for ChatGPT: What activating methods should be used in the lesson about oxygen?

ChatGPT's response: A lesson on oxygen can be lively and engaging for students by using a variety of activating methods. Here are some examples of such methods that can be used in an oxygen lesson:

Experiences and experiments:

Carry out all kinds of experiments involving oxygen, such as combustion, reactions with metals, and oxidation reactions. Ask students to participate

in the experiments, observe the results, and draw conclusions. This will allow them to directly experience the properties of oxygen.

Work in groups:

Divide students into small groups and have them complete tasks or experiments related to oxygen. You can ask groups to plan and conduct their own experiment or to discuss a specific oxygen issue. Allowing group work develops the ability to collaborate and exchange ideas.

Computer simulations:

Use computer simulations or interactive learning tools that allow students to explore the properties of oxygen and how it reacts with other substances. These can be virtual experiments or chemical simulations that allow students to manipulate particles and observe the results.

Discussions and debates:

Organize a discussion about the importance of oxygen in everyday life, the reaction with other substances, or the uses of oxygen in various fields. Encourage students to express their opinions, ask questions and defend their arguments. This develops communication skills and critical thinking.

Research project:

Suggest that students do a research project related to oxygen. This can be research into how oxygen reacts under different conditions, the uses of oxygen in everyday life, or the search for information about new discoveries related to oxygen. The research project develops research skills and independence.

As we can see, ChatGPT lists and describes typical activation methods, but does not give examples of how they can be used in the lesson.

Since ChatGPT mentioned Simulations among the mentioned activation methods, the next question was: List oxygen-related simulations.

ChatGPT's response: Here are some examples of oxygen simulations you can use in your classroom:

Oxidation reaction simulations:

Use interactive simulations that allow students to explore oxidation reactions, such as the reaction of oxygen with metal or the combustion of organic substances. Such simulations make it possible to manipulate particles, observe the results and understand reaction processes.

Breathing simulations:

Use simulations that show the breathing process in both humans and animals. Students can observe how organisms take up oxygen, how it is transported and how carbon dioxide is exhaled. This helps to understand the importance of oxygen in the breathing process.

Atmosphere simulations:

Use simulations that show the structure of the atmosphere and the gas composition of the air. Students can manipulate the levels of oxygen and other gases in the atmosphere, observe changes in composition, and understand how oxygen is available in the air and how it affects various life processes.

Photosynthesis simulations:

Use interactive simulations that show the process of photosynthesis and the role of oxygen in this process. Students can observe how sunlight, carbon dioxide and water are used to produce oxygen and glucose. This allows us to understand the importance of oxygen for plants and the entire ecosystem.

Combustion simulations:

Use simulations that show the combustion process with oxygen. Students can observe how different combustible substances react with oxygen and what products are produced during combustion. This helps to understand that oxygen is necessary to sustain combustion.

Since ChatGPT's answer was very general, another question was asked.

Question for ChatGPT: Can you provide links to these simulations?

ChatGPT's response: Sorry, but as a text model, I can't provide direct links or look up current online resources. However, you can find oxygen-related simulations using popular educational platforms and sites such as:

PhET Interactive Simulations: PhET offers a wide selection of interactive simulations related to chemistry, including oxygen. You can visit their website and search for oxygen simulations.

ChemCollective: ChemCollective is an educational platform with many virtual chemistry experiments and simulations. You can look for simulations of oxygen and its properties there.

Educational online platforms: Educational search engines or platforms such as Khan Academy, Chemix, and ChemEd X contain various educational materials, including oxygen-related simulations.

It is also worth paying attention to the sources and websites of local and regional educational organizations that may provide simulations and resources related to the study of chemistry.

Please note that links and resources are subject to change, so it is always a good idea to look for the most up-to-date and educational materials.

As we can see, the answer is completely unsatisfactory. Apart from the typical pages with life science simulations, no specific links appear.

Following the simulation trail, another question was asked: Question for ChatGPT: Do you know any phone apps about oxygen?

ChatGPT's response: Yes, there are many mobile phone apps related to oxygen. Here are some popular apps that might be useful:

Oxygen Saturation (SpO2) Checker: This is an application that allows you to measure the level of oxygen saturation in the blood using a special infrared sensor that is connected to the phone. It can be useful for monitoring oxygen levels in people with respiratory problems.

Air Quality Index: This is an app that provides information about the air quality in your area. It can contain information about the level of oxygen in the air, as well as other harmful substances, such as pollution or dust.

Periodic Table: Many mobile apps contain a periodic table of chemical elements, including oxygen. You can find apps that provide information about the properties, history, and uses of oxygen.

Chemistry Tools: There are apps that offer various chemistry tools and calculators that can be helpful when learning about oxygen and other chemical compounds. These can be applications for calculating molar masses, chemical equations, etc.

Air Quality Index: This is an app that provides information about the air quality in your area. It can contain information about the level of oxygen in the air, as well as other harmful substances, such as pollution or dust.

Periodic Table: Many mobile apps contain a periodic table of chemical elements, including oxygen. You can find apps that provide information about the properties, history, and uses of oxygen.

Chemistry Tools: There are apps that offer various chemistry tools and calculators that can be helpful when learning about oxygen and other chemical compounds. These can be applications for calculating molar masses, chemical equations, etc.

Please note that the availability of specific apps may vary depending on your

phone's operating system (e.g. iOS or Android) and the region you are in. The app store finder on your phone may provide more information on available oxygen apps.

In response, ChatGPT listed 6 specific applications for the phone and gave places where you can search for more applications. He also drew the teacher's attention to the operating system of the mobile phone and the region. It can be said that the answer, in this case, is a bit more precise than in the simulation.

Another time-consuming job of the teacher is the creation of tests (Cieśla, Nodzyńska, & Paško, 2004). Nowadays, in the era of inclusive teaching, in one class there are both average and disabled children and very talented children. Creating tests in these conditions can be difficult. It was decided to check whether ChatGPT is able to help the teacher in this task. ChatGPT was tasked with creating a test for the acid section. The test was to consist of 10 different questions and was based on Bloom's taxonomy. Then they were asked to create two versions of this test: for children with reduced intellectual abilities and for very gifted children. The effects of ChatGPT's work are listed in Table 4.

Table 4. Tests created by ChatGPT. In the first column, is the original (basic version of the test), in the second column, is the version for children with reduced abilities, and in the third - is for very gifted children. If the questions remained unchanged, the second and third tables were left blank.

The basic version of the test	Children's version with reduced capabilities	A version for very gifted children
1. Multiple choice question: Which of the following substances is an example of an acid? a) Sodium b) Water c) Citric acid d) Oxygen		
2. Matching pairs: Match the correct acid to its characteristics: a) Citric acid It is found in vinegar b) Sulfuric acid Often used in the manufacture of batteries c) Acetic acid Contained in citrus and used as a preservative		

The basic version of the test	Children's version with reduced capabilities	A version for very gifted children
3. Filling the gap: The acid is usually... in the taste. Answer: sour		
4. Short answer question: Give one example of the use of acids in everyday life. three examples ...
5. True/False: Sulfuric acid is safe to consume. Answer: False		
6. Analytical task: Show the chemical reaction between an acid and a base and write the chemical equation. Choice question:	Sulfuric acid is used to produce: a) Battery b) Soaps c) Medicines	Choice question: Sulfuric acid is used to produce: a) Battery b) Soaps c) Medicines
7. Matching Acid Properties: Match the acid property with its description: a) Reacts with metals, releasing hydrogen Hydrochloric acid b) Has a characteristic smell Sulfuric acid c) Changes the color of the pH indicator to red Nitric acid		
8. Research task: Conduct an experiment to study the reaction between acid and hydroxide. Present the results and conclusions.	Research task: Analyze the reaction between acid and hydroxide. Read the content and answer the questions.	Research task: Analyze the reaction between acid and hydroxide. Read the content and answer the questions.
9. Crossword: Complete the crossword using the definitions and names of acids.	Fewer fields to fill	More fields to fill

The basic version of the test	Children's version with reduced capabilities	A version for very gifted children
10. Open question: What questions do you have about acids? Write at least one question.	Open question: What is acid? Write a short definition..	Open question: Explain how a pH indicator works and how it is used to determine acids

As you can see, the questions are very diverse and are actually based on Bloom's taxonomy. However, their correctness leaves a lot to be desired.

In question 1, the distractors are not uniform. The answer C) "citric acid" is distinguished, which contains the word acid in the answer.

Question 2 is correct in English. But in Polish, there is an error in it. The term "kwas siarkowy" appears, in Polish it should be "kwas siarkowy(VI)". Failure to specify valency, in this case, is a serious error.

The 3. question is correct. But it strengthens the common belief that all acids are acidic - and this is not true, e.g. oleic, stearic, boric acid.

In questions 5 and 6 the situation is analogous to question 2.

Task 6, first, is not analytical. Second, I don't know what "Show a chemical reaction" means.

Especially since it says "write a chemical equation" later on.

Question 7: In the case of sulfuric and nitric acid, the situation is analogous to question 2. But I don't know how to assign individual acids to their properties. All of these acids change the color of the pH indicator to red, all have a characteristic smell and all react with metals releasing hydrogen (although the course of the reaction depends on the acid concentration and the metal used). So that question is completely useless.

Question 8 in the basic version is correct. However, I don't know what "Analyze the reaction between acid and hydroxide" means. The wording "Read the content and answer the questions" also appears in the body of the question. But no text to read and no questions. So part of the test for students with disabilities and for more gifted students is not correct.

In question 9. ChatGPT there are no crosswords or even sample questions for them.

It can also be noticed that the differences between the basic version of the test and the tests for less and more gifted children are not large. Questions 1, 2,

3, 5, and 7 are identical (which is 50% of the test). In questions 6 and 8, the tasks for gifted students are the same as for weaker students, much simpler than in the basic version of the test. Only in question 10, 3 versions of the question with the appropriate level were proposed. It can therefore be concluded that ChatGPT cannot be used to create different versions of the same test, and when using it to create tests, the teacher must be vigilant and correct any mistakes.

According to prof. Gerald Hüther (2012), the learning process becomes effective when the student is responsible for learning and directing his development. The role of the teacher should be to support the student and monitor his progress (Nodzyńska, & Cieśla, 2016). Formative Assessment is one way to achieve this. Formative assessment is a way of working for the teacher and students, which consists in systematically obtaining information about the course of the learning process. Thanks to it, the teacher can modify further teaching and give students feedback to help them learn. Since writing individual answers for each student is time-consuming, it was decided to check whether ChatGPT could replace us in this activity.

Question for ChatGPT: Using formative assessment, rate the following student work: “Acids are a family of liquid chemicals that taste sour and are corrosive. Acids have a pH less than 7. They react with metals.”

ChatGPT’s response: Formative assessment is an assessment approach designed to support student development by continuing the learning process and providing constructive feedback. When evaluating the student’s work as described in the question, several aspects can be taken into account:

Correctness of the information: The student’s work states that acids are a family of liquid chemical compounds that taste sour and are corrosive. This information is correct because acids are chemical compounds that taste sour and can be corrosive.

Accuracy of definition: The student defined acids as sour-tasting and corrosive substances. However, some precision in the definition is lacking. The student could be encouraged to add that acids are substances that donate hydrogen ions (H^+) in an aqueous solution.

pH of acids: The student pointed out that acids have a pH of less than 7. This is correct because acids have a lower pH than 7, which means they are acidic.

Reactions with metals: The student found that acids react with metals. This is correct as many acids do indeed react with metals to release hydrogen.

In general, the student’s work contains the correct information about acids, but some definitions may require more precision. To support the student’s further development, constructive feedback could be provided that clarifies definitions

further and encourages further exploration. Formative assessment should focus on support and development

Formative assessment should focus on supporting and developing the student’s skills, not just on the final assessment.

Although ChatGPT has listed exactly what elements should be included in the descriptive assessment for a student, make many mistakes. So another task was given.

Question for ChatGPT: The student’s answers are not correct: not all acids are liquids, and not all acids taste sour or are caustic. He should also write that most acids react with metals - not that “they react” - this assumes that they should all react.

ChatGPT’s response: Sorry for the imprecise answer. Indeed, the student’s answers contain incorrect or imprecise information about acids. The correct answers are: Acids are a family of chemical compounds that can be in various states of aggregation, such as liquids, solids, or gases. Not all acids are liquids. Sour taste and corrosive properties are not common to all acids. In fact, some acids can be odorless or even sweet in taste. In contrast, corrosive properties are characteristic of some acids, such as sulfuric acid, but not all acids. It is correct to say that most acids react with metals to produce hydrogen. However, not all acids react with metals and some can react with other chemicals.

ChatGPT corrected HIS answer - but did not write a grade for the student’s work. It seems that this task is beyond his capabilities.

Discussion

Summing up the use of ChatGPT to support the teacher’s work, it can be said that in some areas the teacher can do it with ChatGPT. However, many ChatGPT activities must be supervised by the teacher, provide further information or correct errors made by ChatGPT. (Tab. 5).

Table 5. Evaluation of individual ChatGPT activities.

ACTION	evaluation	more info
Antitheme	:(After several leads, the antitheme was obtained, but the content assigned to it was not correct
Bloom Lesson Objectives	:)	
Lesson Objectives Niemierko	:	Good after giving the definition of goals according to Niemierko

ACTION	evaluation	more info
Student Success Criteria	:)	
Lesson outline	:)	In the original version, a traditional outline of the giving lesson was created, after correcting the question → he created a constructivist outline
Lesson plan (drama)	:)	After asking an additional question → examples, scenarios of played dramas
Experiments	:	Inaccurate descriptions, not suited to the lesson
Activation methods	:	General methods are given, but no specific solutions
Simulation links	:	Listed are not links but names of popular sites
Phone apps	:)	
Test (10 different tasks based on Bloom's theory)	:	The tasks are varied but contain errors
Adaptation of the test (for a weaker and more talented student)	:(50% of the questions remained the same, 2 questions the same for the more gifted and weaker students
Formative Assessment	:(The work has not been evaluated

Summarizing the number of tasks performed correctly and incorrectly (Tab. 6), we can conclude that ChatGPT will not replace the teacher in preparing for the lesson. However, several areas (such as specifying goals for a given topic, success criteria or even writing a lesson outline according to the teacher's assumptions) are mastered very well. It seems that in these areas we can fully use his help.

Table 6. Summary of the assessment of ChatGPT's performance of individual tasks.

:)	:	:(
5	5	3

Conclusions and Implications

The question arises - If ChatGPT is able to replace the teacher in such basic activities as: setting lesson objectives, providing success criteria or even writing a lesson outline, then how to educate future teachers? Will these skills be necessary?

Ethics Statement

The ethics committee confirmed to the corresponding author that this research did not require ethics approval because of the full anonymization of the publicly available data and because the data are not sensitive.

Conflicts of Interest

The authors declare no conflict of interest.

References

- Bloom, B. S.; Engelhart, M. D.; Furst, E. J.; Hill, W. H.; Krathwohl, D. R. (1956). Taxonomy of educational objectives: The classification of educational goals. Vol. Handbook I: Cognitive domain. New York: David McKay Company.
- Burewicz, A., Jagodziński, P., & Wolski, R. (2008). *Metodyka eksperymentu chemicznego*. Gimnazjum. Wprowadzenie do chemii, tlen i tlenki, woda i roztwory wodne, Poznań: Uniwersytet im. Adama Mickiewicza, Wydział Chemii, Zakład Dydaktyki Chemii.
- Cieśla, P., Nodzyńska, M., & Paško, J. R. (2004). Zadania otwarte czy zamknięte - czyli jak sprawdzić wiedzę ucznia In. *Badania w Dydaktyce Chemii* (ed. Paško, J. R.) Kraków: Wydaw. Naukowe AP, pp. 39-48.
- Cieśla, P., Nodzyńska, M., & Paško, J. R. (2007). The role of didactics of chemistry in moulding teachers' priorities of goals in chemical education In. *Proceedings of the 2nd European Variety in Chemistry Education* (ed. Nesměrák, K.) Prague: Charles University. Faculty of Science, pp. 44-47.
- Hattie, J. (2015). The applicability of Visible Learning to higher education. *Scholarship of Teaching and Learning in Psychology*, 1(1), 79–91. <https://doi.org/10.1037/stl0000021>
- Hüther, G & Hauser, U. (2012). *Jedes Kind ist hoch begabt: Die angeborenen Talente unserer Kinder und was wir aus ihnen machen*, Albrecht Knaus Verlag.
- Jyż-Kuroś, D., & Nodzyńska, M. (2022). Jak zapakować, aby dostosować? - koncepcja grupowania wiadomości i umiejętności w oparciu o zrewidowaną taksonomię Blooma w uczeniu pisania równań reakcji chemicznych In. *Doskonalenie dydaktyki szkolnej i akademickiej* (eds. Chrzanowski, M. M., Żeber-Dzikowska, I., Chmielewski, J.) Warszawa: Instytut Ochrony Środowiska - Państwowy Instytut Badawczy, pp. 76-88, <http://ios.edu.pl/wp-content/uploads/2022/10/Doskonalenie-dydaktyki-szkolnej-i-akademickiej.pdf>
- Kaczmarzyk, M. (2018). *Szkoła neuronów*, Słupsk.

- Mastalerz, E. (2006). Jak pisać konspekt lekcji? *Annales Academiae Paedagogicae Cracoviensis Studia Technica I* UP, Kraków.
- Niemierko, B. (2021). *Diagnostyka Edukacyjna*. PWN.
- Nodzyńska, M. (2005). Rola doświadczeń chemicznych jako jednej z metod kształcenia. *Acta Facultatis Paedagogicae Universitatis Tyrnaviensis. Ser. D, Supplementum 1*. 2005, no. 9, pp. 233-236.
- Nodzyńska, M. (2018). Eksperymenty przyrodnicze w nauczaniu formalnym, pozaformalnym i nieformalnym In *Edukacja przyrodnicza - klasyka czy nowoczesność?* (eds. Pilichowski, S. & Żeber-Dzikowska, I.) Zielona Góra: Uniwersytet Zielonogórski, pp. 271-283.
- Nodzyńska, M., & Cieśla, P. (2015). Scientific theatre as a popularizing knowledge of natural sciences. *Annales Universitatis Paedagogicae Cracoviensis. Studia ad Didacticam Biologiae Pertinentia*. 2015, Z. 5, pp. 22-31. UP, Kraków.
- Nodzyńska, M., & Cieśla, P. (2016). Zaliczył czy nie zaliczył - jak sprawiedliwie oceniać, *Niezbędnik Kadry Akademickiej*. 2016, no 8, pp. 28-36.
- Nodzyńska, M., & Paśko, J. R. (2002). *Przyroda: konspekty o tematyce chemicznej. Cz. 1, Rozwiązania dydaktyczne i wyniki badań nad ich skutecznością*. Krzeszowice: Kubajak, 40 p.
- Paśko, J. R., Nodzyńska, M., & Tejchman, W. (2002). *Konspekty lekcji chemii do gimnazjum. Cz. 1*. Krzeszowice: Wydaw. Kubajak, 122 p.
- Way, B. (1990). *Drama w wychowaniu dzieci i młodzieży*. Warszawa, WSiP.

Małgorzata Nodzyńska-Moroń

*Department of Technical and IT Education, Institute Of Technical Sciences,
Pedagogical University, Kraków, Poland*

malgorzata.nodzyńska-moron@up.krakow.pl

Pass rate of students of Chemistry Teaching at final state exam:

Case study analysing influences on success rate of students with stress on distance learning during Covid-19 pandemic

Patrik Pospíšil, Veronika Švandová, Jaromír Literák

[DOI 10.24917/9788368020403.4](https://doi.org/10.24917/9788368020403.4)

Abstract

This case study deals with the influences on success rate of bachelor students of Chemistry Teaching at final state exams at Faculty of Science of Masaryk University in Brno. The extraordinarily low pass rate of the students at the exam test occurred in 2022. For this reason, the inquiry was launched to map the situation and identify the causation.

Within the case study, two research methods were used – statistical analysis of the test results and questionnaire survey for involved students. The students finishing their studies in 2022 attended many important courses during the period of Covid-19 pandemic. With regard to this fact, some of the queries in the questionnaire were related to evaluation of distance learning.

Based on obtained results, modifications of setup and content of the final state exam in chemistry were proposed for following year in order to help students. Several adjustments of test construction and exams organisation were implemented in 2023. Simultaneously, the noticeable increase in success rate of Chemistry Teaching students was observed in that year.

Key words

chemistry teaching; achievement test; final state exam; distance learning; case study

The context and purpose of the framework

Students of all chemically focused study programmes at Faculty of Science of Masaryk University in Brno finish their bachelor studies by defending the

final thesis and passing the final state exams. In case of the bachelor programme Chemistry with a view to Education (a study programme for future chemistry teachers), the students take three different final state exams. One of them is naturally an exam in chemistry. The second one is an exam in their second field of study as students of teaching have two specialisations (for instance a combination of chemistry with biology, mathematics, physics, or another domain). The third exam is an achievement test which includes fundamental knowledge of pedagogics, psychology, and didactics (instructional science).

The final state exam in chemistry has a form of an achievement test which is composed of five parts. Each part of the test covers different field of chemistry including inorganic, analytical, physical, organic chemistry, and biochemistry.

In the spring term 2022, the unprecedentedly low pass rate of bachelor students of Chemistry Teaching at final state exam occurred. Only 9 of 20 students successfully passed the exam test in that year. This implied a logical question what the main causes of the failure of majority of students were. The source of such problem could lie either in the educational process or in the construction and organisation of the exam test. To determine possible causation and examine the issue, the inquiry was initiated. Two research tools were used for the purpose of investigation – statistical analysis of the test results and questionnaire survey for involved students. In questionnaire, students were supposed to express their experience and opinions related to their study and the final exam.

It is important to point out that during the Covid-19 pandemic, distance learning was carried out on all levels of education including universities. It follows that students finishing their studies in 2022 were affected by this situation. The pandemic measures were commenced in March 2020, during the second term of their bachelor study. Therefore, the concerned students attended most of crucial courses during the pandemic period. Namely, this applied to the fundamental subjects Inorganic chemistry II, Organic chemistry I and II, Physical chemistry, Analytical chemistry, and Biochemistry. The enumerated courses are obligatory and constitute a core of the chemistry studies.

It is obvious that mentioned conditions could significantly influence the education of concerned students. Therefore, we decided to include this subject in launched inquiry. For this reason, some queries involved in the used questionnaire were focused on implementation of distance learning.

To highlight the relevance of the topic, we can see that the pedagogical research across the world was strongly focused on influences of distance learning in last years. The results of the mentioned research were summarised in many recently published articles. Conclusions presented in publications dealing with the impact of distance learning to students in higher education could serve us as a reference point for planning of the survey. [1-3]

Research methods

As already mentioned above, two research methods were used within the case study – statistical analysis of the test results and questionnaire survey for involved students. Both research tools are described separately in the following paragraphs.

Statistical analysis of the test results

Within the study, only results of Chemistry Teaching students at final state exam were analysed. The analysis involved determining the location and scale parameters of the test and its individual parts. The next step was determination of difficulty and sensitivity of each test part and the single test tasks.

Characterisation of analysed test

The exam test consisted of five parts involving inorganic, analytical, physical, organic chemistry, and biochemistry. Each section included test tasks for 8 points, and hence maximum total score was 40 points. The limit for passing the exam was 45% (i.e., 18 points) in total. There are not any requirements for reaching the certain number of points in the individual parts.

Inorganic, analytical, physical chemistry and biochemistry parts were composed of multiple-choice tasks. In contrast, organic chemistry part was composed of open-ended tasks (for answering via drawing structures).

Twenty students of Chemistry Teaching took part in analysed exam test.

Explanatory note: The final state exam in 2022 was held in two dates. In February, when 6 students of Chemistry Teaching took part and in June, when 20 students took part. Therefore, the statistical analysis deals only with the results of June test variant when majority of students attended.

Questionnaire survey for involved students

The purpose of the survey was collecting data from concerned students. The respondents were asked to express their experience, opinions and feelings connected to their study at university and to the final exam test. The questionnaire dealt with overall assessment of the study and also with evaluation of individual core subjects (i.e., the fundamental subjects covering the five areas of the final state exam test in chemistry).

As discussed in the introduction, important part of the questionnaire were queries related to implementation of distance learning during the period of Covid-19 pandemic. The respondents were supposed to evaluate the impact of that situation on their study in terms of their internal and external motivation, the level of knowledge they achieved in particular branches of chemistry etc.

Characterisation of used questionnaire

The used questionnaire consists of 18 items. The items involve Likert-type scale, dichotomic (yes/no), open-ended, and multiple-choice questions with multi-select answers.

The Microsoft Forms was utilised as a tool for both creating of the questionnaire and collecting the data from respondents. The respondents were asked to participate in the survey via message sent out to their university e-mail addresses.

Within the survey, 18 respondents participated (out of 26 addressed students). The majority of them (11 students) were willing to answer under their identity. The rest of the responses were sent anonymised.

Results and discussion:

Results of the final state exam in chemistry in June 2022.

In June 2022, twenty bachelor students of Chemistry Teaching took a final state exam in chemistry. Distribution of overall test score (see Figure 1) shows that only 9 students successfully passed the exam test and remaining 11 students failed. The requirement for passing the exam was 45% (i.e.,18 points) in total.

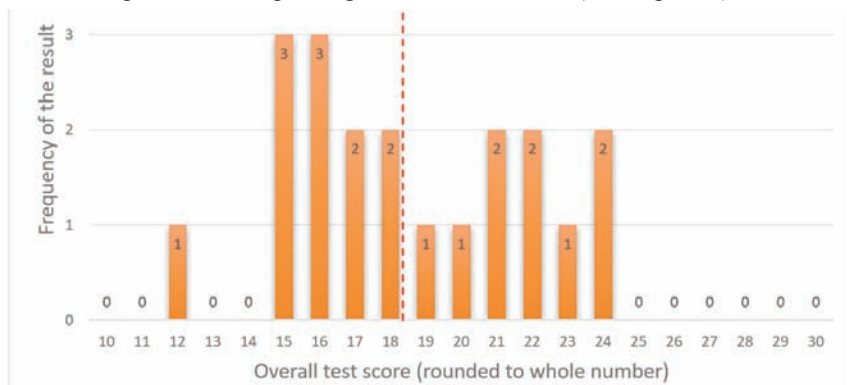


Figure 1. Distribution of overall test score – sum of all five parts (the passing limit is represented by dashed red line)

Basic location and scale parameters of the exam test in June 2022 were following:

arithmetic mean: 18.58 points

median: 17.70 points

standard deviation: 3.19 points

coefficient of variation: 0.172, i.e., 17.2%

Regarding individual sections of the test, it was obvious that the difficult fields for students were biochemistry and inorganic chemistry. Average score of both mentioned areas were significantly under the 45% (3.6 points). Local parameters of all single parts are presented in following graph.

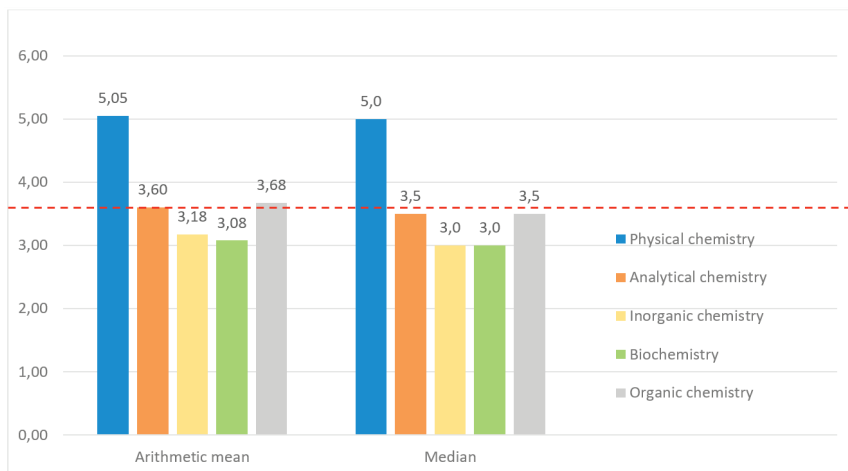


Figure 2. Local parameters of individual test parts (dashed red line highlights the 45% of score)

Especially in the case of biochemistry, the analysis revealed problems in several aspects. For this reason, the results of inquiry for this section are introduced in more detail. Basic location and scale parameters of the biochemistry test part in June 2022 were following:

arithmetic mean: 3.08 points

median: 3 points

standard deviation: 1.09 points

coefficient of variation: 0.355, i.e., 35.5%

The average value of difficulty index (P) for test tasks from this section is 0.384 (38.4%) which is significantly under the 45% level. As an illustration, one particular task had its P-value equal to zero (none of students answered this question correctly). In additional, determined values of the discrimination coefficient (D) for test tasks from this section are very low. The average D-value is close to zero which means that this part of the test does not have an ability to discriminate, and hence is not sensitive. This indicate that some students might even reply in a random manner.

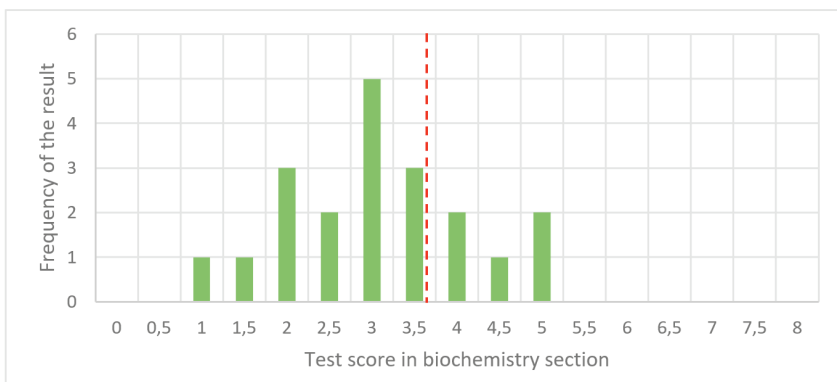


Figure 3. Distribution of test score in biochemistry section

(dashed red line highlights the 45% of score)

Choose the statements related to **biochemistry part** of final state exam you consider true.

- The exam test contained tasks which were not covered by syllabus of final state exam.
- The required knowledge for final state exam was not included in related course.
- The difficulty of final exam test was higher than the difficulty of exam test in related course.
- Current form of final state exam in biochemistry does not correspond with form of exam in related course.
- I was not sufficiently informed how shall I prepare for the final state exam properly.
- I did not have enough time to concentrate on this field.
- Range of tested knowledge was appropriate.
- Others

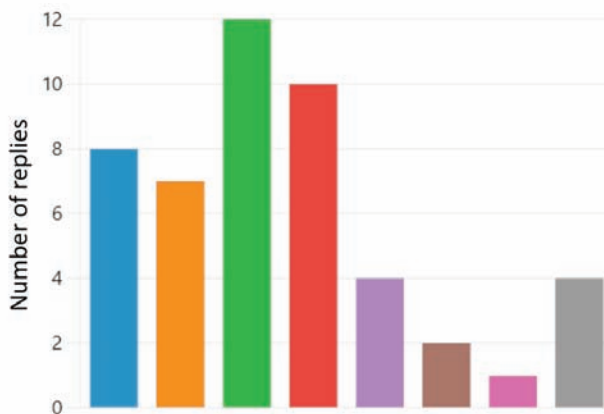


Figure 4. Summarisation of assessment of biochemistry test part in questionnaire

(results of questionnaire survey)

Based on questionnaire replies, we could see the critical assessment of this exam test part. Introduced graph summarises replies to item with instructions: “Choose the statements related to biochemistry part of final state exam you consider true.”

Two thirds of respondents (67%) considered the difficulty of this test part higher than difficulty of exam in corresponding course. Almost half of respondents (44%) expressed an opinion that the test contained tasks which were not covered by syllabus of final state exam. Only one respondent considered the range of tested knowledge appropriate.

In contrast to low average test score in this area, students subjectively evaluated the level of knowledge they had reached during their study as sufficiently high (see Figure 5). Average reported value was 3.61 on a rating scale from 1 (very low level) to 5 (very high level of knowledge).

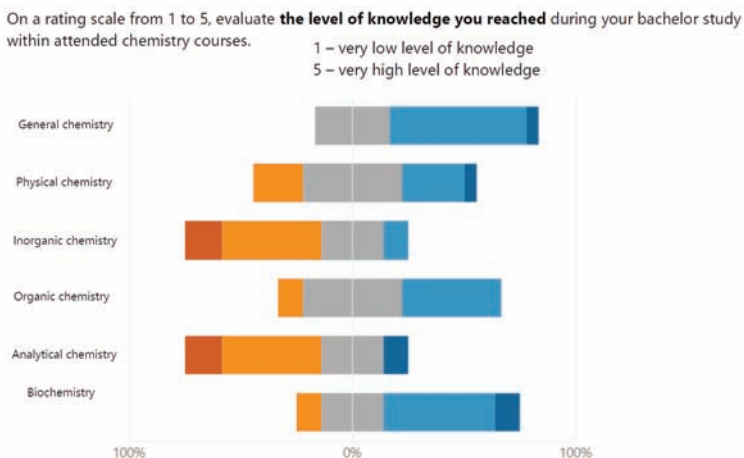


Figure 5. Self-evaluation of reached level of knowledge (results of questionnaire survey)

Simultaneously, the teaching style and methods of corresponding course and seminar were assessed as positively motivating for gaining of knowledge (see Figure 6). Average reported value of motivation was 0.61 on a scale from -3 (maximal demotivation) to 3 (maximal motivation) which is the highest value of evaluated subjects.

Presented data indicate that we must discriminate between assessment of content and form of final state exam in biochemistry and evaluation of teaching of biochemistry during bachelor study. To sum up, we could briefly say that

respondents evaluated biochemistry courses positively but on the other hand assessed final state exam test negatively.

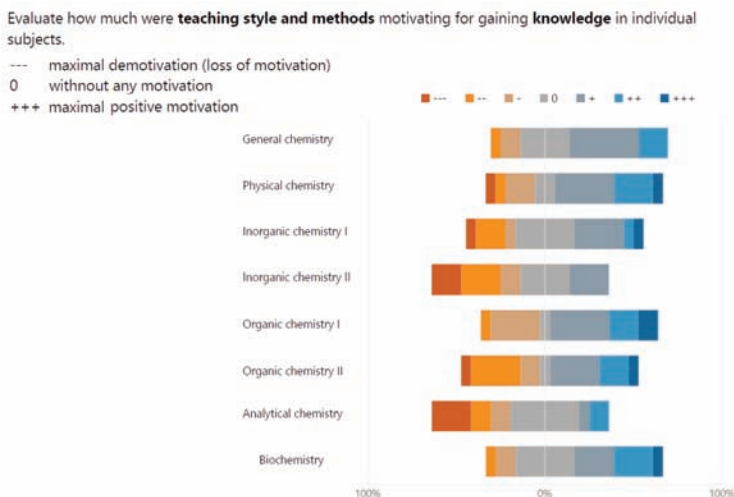


Figure 6. Evaluation of teaching style and methods

The last two introduced graphs (see Figures 5 and 6) are related to all core subjects which cover syllabus of bachelor final state exam in chemistry in June 2022. Therefore, the evaluation of general, physical, analytical, inorganic, and organic chemistry is also involved there. For this reason, the results for this test areas are presented in more concise form.

On the basis of determined indexes of difficulty and discrimination, physical chemistry test part of the exam appeared to be properly constructed. This statement is supported by positive feedback from students via questionnaire survey. The vast majority (83%) of respondents considered the range of tested knowledge appropriate. Simultaneously, the respondents replied that they received sufficient information about content and form of the exam (any of respondent did not express the opposite opinion). The teaching style and methods of related course were also assessed positively – average reported value of motivation was 0.5 on a scale from -3 to 3.

For analytical chemistry test part, the average value of P-index was relatively low (0.45 which is on the passing level). Two particular test task had values of P close to zero. It corresponds to opinion of respondents (77%) who considered the difficulty of this test part higher than difficulty of the exam in related course. The average value of D-index (0.18) was quite low as well which indicated decreased sensitivity of this test part. Parallely to the low success rate in this area, students considered the analytical chemistry a problematic field. The respondents assessed

the level of knowledge they reached during bachelor study as quite bad. Average reported value was 2.44 on a scale from 1 to 5.

The inorganic chemistry test part was problematic in a viewpoint of low average value of P-index (0.39) which is under the passing level. It corresponds with critical stance of students via questionnaire replies. On the other hand, it is needed to mention that the values of D-index indicated sufficient sensitivity. These findings could signify that the test part was constructed appropriately but this field was difficult for students as itself. In questionnaire, half of the respondents replied that they had not had enough time to prepare properly for this area of the final exam. The respondents also evaluated their level of knowledge in inorganic chemistry as low. Average reported value was 2.33 on a rating scale from 1 (very low level) to 5 (very high level of knowledge). It is connected to the fact that students considered the teaching style and methods of related courses and seminars as demotivating. Average reported value of motivation was -0.42 on a scale from -3 (maximal demotivation) to 3 (maximal motivation) which is the lowest value of evaluated subjects.

The organic chemistry test part could be considered relatively difficult for students because the average value of P-index (0.46) was close to the passing level. But in terms of difficulty and sensitivity, it is necessary to add that there was not any single problematic test task (a task with very low values of P and D-index). Simultaneously, the students evaluated this area in exam and its related courses positively in several aspects. The respondents evaluated the level of knowledge they reached in organic chemistry as sufficiently high. Average reported value was 3.33 on a rating scale from 1 to 5. Majority of respondents (78%) considered the range of tested knowledge adequate. The respondents also replied that they received sufficient information about content and form of the exam and that they had enough time to prepare for the exam. Hence, this test part can be regarded as properly constructed.

Influence of distance learning on the final state exam in chemistry in June 2022

As discussed earlier in the text, significant part of the questionnaire were queries focused on implementation of distance learning during the period of Covid-19 pandemic. Based on questionnaire replies, we were able to identify several trends in opinions of participating students.

In terms of distance learning during Covid-19 pandemic, respondents experienced the loss of both internal and external motivation. They also mentioned problems with concentration and holding attention. On the other hand, the loss of interest in chemistry and loss of determination to become a teacher did not occur widely among the students. The most of respondents also agreed that insufficient technical equipment was not a major issue. The following graph (see Figure 7)

summarises the results of student evaluation of factors connected to Covid-19 pandemic with influence on bachelor study of Chemistry Teaching.

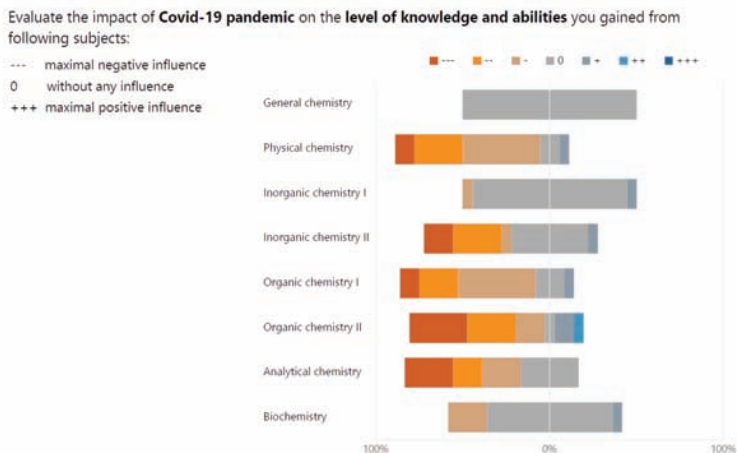


Figure 7. Evaluation of factors connected to Covid-19 pandemic with influence on bachelor study of Chemistry Teaching

With regard to impact of Covid-19 pandemic, students also stressed out the negative effect of distance learning on the level of knowledge and skills they gained from almost all individual core subjects. Respondents pointed out strongly negative effect of distance learning to courses dealing with physical, inorganic, organic, and analytical chemistry. The item focused on this question had a form of a seven-point rating scale from maximal negative to maximal positive influence of Covid-19 pandemic to the courses (see Figure 8).

Explanatory note: Involved students attended the subjects General chemistry and Inorganic chemistry I during first term of their study before Covid-19 pandemic.

To summarise introduce finding, we can say that the concerned students perceived implementation of distance learning and other factors connected to Covid-19 pandemic as a substantial obstacle in their bachelor study.

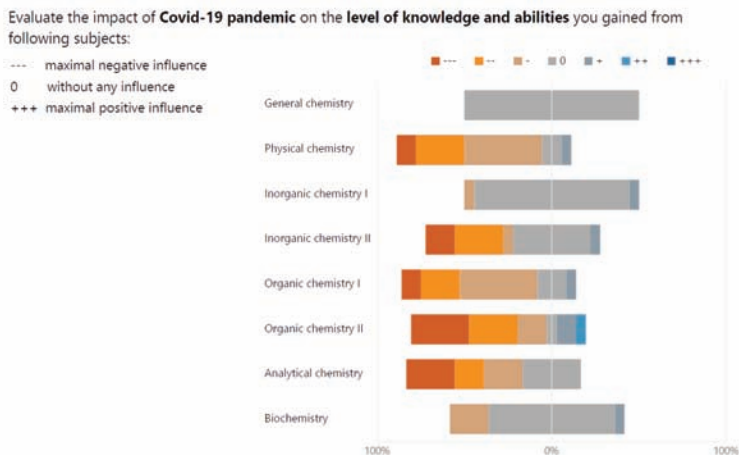


Figure 8. Evaluation of Covid-19 pandemic impact on the level of reached knowledge

Form and organisation of the final state exam test in chemistry in June 2022

Within the questionnaire survey, the students were also asked to give their opinion on the form of the final state exam in chemistry (see Figure 9). The majority of respondents (61%) consider current form (i.e., written test) of the final exam optimal. The minority (28%) would prefer a combination of written and oral exam. Only two respondents (11%) favoured solely oral form of the final state exam in chemistry.

What **forms of final state exam** do you consider optimal?

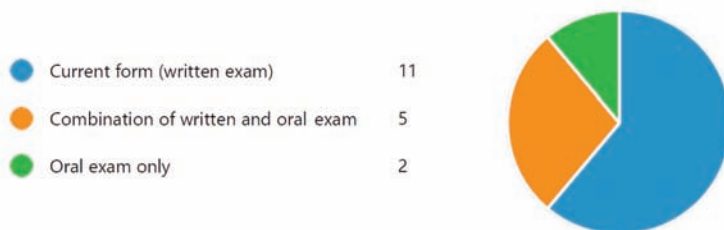


Figure 9. Opinions on form of the final state exam

In terms of character of the involved test tasks, majority of the students agreed that they would prefer increase in number of open-ended questions and simultaneous reduction in number of multiple-choice tasks (see Figure 10).

Which **types of test tasks** do you prefer in written final state exam test in chemistry?

Less – I would prefer lower number of this task type compared to current state.

Same number – I am satisfied with current state.

More – I would prefer higher number of this task type compared to current state.

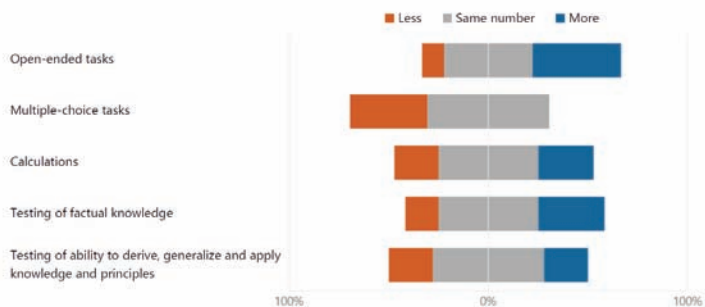


Figure 10. Opinions on character of the test tasks in final state exam

Which **types of test tasks** do you prefer in written final state exam test in chemistry?

Less – I would prefer lower number of this task type compared to current state.

Same number – I am satisfied with current state.

More – I would prefer higher number of this task type compared to current state.

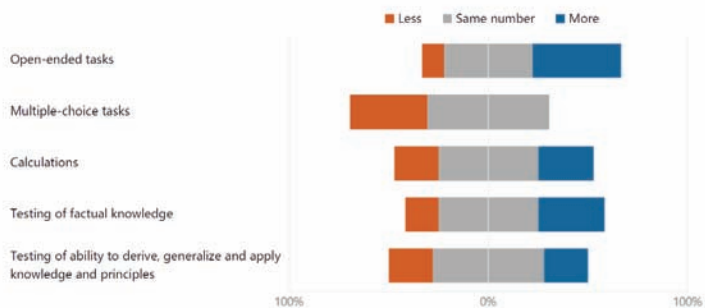


Figure 11. Factors influencing the result of final state exam in chemistry

Regarding the organisation of the final state exams, students stressed out the problems connected to timing of individual exams. In questionnaire item focused on this topic, the majority of respondents (61 %) answered that they were struggling due to close time proximity of the final state exam in chemistry and the exam in second field of study (see Figure 11). Some respondents even described the problem of the close time proximity of exams as a major issue for them in open-ended item in the end of the questionnaire. It was associated with

the fact that the time period between final exams in chemistry and biology was very short in June 2022 (the student have only one free day to recover between these two exams).

Implemented modifications of the final state exam in chemistry in June 2023

In August 2022, the results obtained from carried inquiry were summarised and analysed. Subsequently, several modifications concerning organisation of final state exam and content of the used achievement tests were suggested. After discussions between organisers of the final state exams, some of the proposals were accepted and introduced for following year.

On the basis of student replies in questionnaire, the composition of test was adjusted with intention of including more open-ended test tasks in June 2023 final state exam in chemistry. The modified version of physical, analytical, inorganic chemistry, and biochemistry test parts included open-ended questions. Number of tasks in each section (8 tasks) was preserved but two of them were replaced by open-ended questions. In organic chemistry test part, two multiple-choice tasks were included with contrary to previous years. Therefore, each part newly contained both open-ended and multiple-choice tasks. The physical, analytical, inorganic chemistry, and biochemistry test parts were predominantly composed of multiple-choice tasks (6 out of 8 task). And analogously, the organic chemistry test part comprised primarily of open-ended tasks (for possibility of drawing structures and schemes).

With regard to construction of the exam test, the effort was made to optimize the problematic test parts. The authors of individual sections tried more to build up the final exam test with respect to content, form and difficulty of the exams in corresponding courses.

In order to increase the awareness of students about the content and form of final state exam in chemistry, the set of illustrative test tasks from every tested area was created. The set was included in the official summary of requirements for the final state exam in chemistry in 2023.

The organisers of the final state exams made an effort to prevent the above-mentioned complications with timing due to close time proximity of individual tests. They cooperated to schedule dates of the exams more considerately for students of teaching.

Results of the final state exam in chemistry in June 2023

In June 2023, eighteen bachelor students of Chemistry Teaching took a final state exam in chemistry. The results show that 13 students successfully passed the exam test and remaining 5 students failed. The requirement for passing the exam was 45% (i.e., 18 points) in total.

Basic location and scale parameters of the exam test in June 2023 were following:

arithmetic mean: 20.35 points

median: 20.42 points

standard deviation: 4.49 points

coefficient of variation: 0.221, i.e., 22.1%

In comparison with previous year, we could observe a noticeable increase in the success rate of students at final state exam in chemistry in June 2023. In 2022, the passing rate was 45% (9 out of 20 students) and in 2023, it was 72% (13 out of 18 students).

We plan to continue with observing and analysing results of the final state exam in chemistry of the students of Chemistry Teaching in following years. The purpose is to properly evaluate effect of implemented modifications and contemplate further steps.

Conclusion

As discussed across the text, the aim of this case study was to identify and describe the factors influencing success rate of bachelor students of Chemistry Teaching at final state exams at Faculty of Science of Masaryk University in Brno. The motivation for initiating the inquiry was the situation in Spring term 2022 when the unprecedentedly low pass rate of Chemistry Teaching students at the bachelor final exam test was observed. Statistical analysis of the test results and questionnaire survey for concerned students were used as research tools within the case study. The students finishing their studies in 2022 were affected by pandemic measures as they attended some of the crucial chemistry courses during the distance learning period. With respect to this situation, some of the queries in the questionnaire were focused on evaluating the influence of Covid-19 pandemic on their study and level of knowledge they reached in individual areas of chemistry.

The results of statistical analysis using determination of difficulty and sensitivity of the test tasks (via calculation of P and D-index) uncovered some problematic tasks and test sections. To gain the complete picture, the individual areas were evaluated via results of questionnaire survey as well. On the basis of both mentioned sources of data, physical chemistry and organic chemistry test parts of the exam appeared to be properly constructed. The inorganic chemistry test part showed to be a difficult area for involved students which was also reported in their replies in the questionnaire. However, the test part appeared to be appropriately constructed based on the sufficient sensitivity of its test tasks.

In case of analytical chemistry and biochemistry test part, the statistical analysis pointed out insufficient sensitivity in combination with high difficulty of the test task. For this reason, we suggested to reconsider the construction of these test sections.

The survey proved that we must discriminate between assessment of the content and form of final state exam parts and the evaluation of corresponding courses during bachelor study. For instance, the biochemistry courses obtained positive feedback from involved students with contrary to their bad results at the exam test.

In terms of assessment of education during Covid-19 pandemic period, the questionnaire replies clearly showed that the concerned students perceived implementation of distance learning and other factors related to that situation as a significant obstacle in their bachelor study.

Within the form of exam test, majority of the respondents agreed that they would prefer increase in number of open-ended questions with simultaneous reduction in number of multiple-choice tasks. Because of that, the proposed modification was to incorporate open-ended tasks to all tested areas.

With regard to organisation, students strongly stressed out the problems connected to timing of final state exams due to close time proximity of the individual exams. Therefore, we suggested to schedule dates of the exams more considerably for students of Chemistry Teaching.

The mentioned recommendations for following year combined findings from both statistical analysis and questionnaire survey. Based on these suggestions, several modifications in construction of the exam test and organisation of the final state exams were implemented in 2023. At the same time, the perceptible increase in pass rate of Chemistry Teaching students occurred in that year which was the main purpose of introduced adjustments.

We plan to continue with collecting and analysing the data in following years in order to properly evaluate effect of implemented modifications and consider other options in the future for possible improvement.

We are aware of fact that this work is a case study dealing with a particular situation and hence, we cannot declare our attitude in solving of described problems as universal. On the other hand, we hope that presented data could be potentially interesting or useful for our colleagues and other researchers as well.

Ethics Statement

The ethics committee confirmed to the corresponding author that this research did not require ethics approval because of the full anonymization of the publicly available data and because the data are not sensitive.

Conflicts of Interest

The authors declare no conflict of interest.

Acknowledgements:

We would like to thank all co-operating students who decided to help us and invested their time to fulfilling the questionnaire.

References

- Masalimova, A. R., Khvatova, M. A., Chikileva, L. S., Zvyagintseva, E. P., Stepanova, V. V., & Melnik, M. V. (2022). Distance Learning in Higher Education During Covid-19. *Frontiers in Education*, 7. <https://www.frontiersin.org/articles/10.3389/educ.2022.822958>
- Altawalbeh, K. & Al-Ajlouni, A. (2022). The impact of distance learning on science education during the pandemic. *International Journal of Technology in Education (IJTE)*, 5(1), 43-66. <https://doi.org/10.46328/ijte.195>
- Wang, Y. (2023). The research on the impact of distance learning on students' mental health. *Education and Information Technologies*. <https://doi.org/10.1007/s10639-023-11693-w>

Patrik Pospíšil^{1,2}, Veronika Švandová², Jaromír Literák²

¹Palacký University, Faculty of Science, Department of Inorganic Chemistry

²Masaryk University, Faculty of Science, Department of Chemistry

posppa12@prfnw.upol.cz, 451091@mail.muni.cz

Impact of multimedia on changing students' knowledge of general selective waste separation

Aleksandra Rozbicka, Małgorzata Nodzyńska-Moroń

[DOI 10.24917/9788368020403.5](https://doi.org/10.24917/9788368020403.5)

Abstract

In Poland, the obligation to segregate municipal waste into 5 fractions: bio-waste, metals and plastics, glass, paper has been widespread since 1 July 2017.

The research subject deals with students' knowledge of general waste segregation and the role of multimedia in changing the approach. The subjects of the research are students - of different years, studying different subjects. The subject of the research is to determine the level of students' knowledge on general waste segregation and to check whether multimedia will increase knowledge on the given topic.

A diagnostic survey using a questionnaire technique was chosen as the research method. The results of the study show that despite the passage of 6 years since the introduction of standardised waste segregation, students have not assimilated knowledge at the level of non-intrusive segregation.

Keywords

waste segregation, fractions, standardised waste segregation system, waste bins, ecology.

The context and purpose of the framework

Selective waste segregation in the Republic of Poland came into force on 4 January 2017. The Regulation of the Minister of the Environment of 29 December 2016 on the detailed manner of selective collection of selected waste fractions, made available in the Journal of Laws, introduced five special segregated bins. Through the quoted act, the following waste should be collected selectively in Poland:

- “1) paper;
- 2) glass
- 3) metals

4) plastics;

5) biodegradable waste, with particular emphasis on bio-waste.” (OJ 2017, item 19, paragraph 8).

The aforementioned act standardised the division of segregated waste by introducing containers of the specified colour for the individual wastes. Paper as well as cardboard packaging were allocated to the blue container marked ‘Paper’.

Glass and glass waste were allocated to a green container with the word “Glass” written on the container. It has also been stipulated that, if in an area the segregation is divided into coloured glass and colourless glass, the waste should be placed by default as follows: glass packaging and colourless glass in containers marked ‘Clear glass’, while glass packaging and glass waste having colour in green containers marked ‘Coloured glass’.

The yellow container labelled ‘Metals and plastics’ should be used for metal, plastic and multi-material packaging waste. Biodegradable waste has been designated to the brown coloured bins with the word ‘Bio’ written on them. It was also indicated that if the coloured containers would threaten the aesthetic value of a given place, in particular historic and natural sites, the waste containers may have the colour of the chosen colour, but must have no less than 30% of the colour appropriately assigned to the chosen fraction.

Thus, the Ordinance of the Minister of the Environment introduced an obligation on municipalities to allow selective collection of waste fractions at places designated for public benefit. From the date of entry into force of the ordinance, up to 5 years, municipalities were obliged to replace current containers, with new, coloured containers with assigned fractions. By six months after the ordinance came into force, the municipalities were required to sign the containers with the appropriate fractions, thus assigning to them the relevant waste, i.e. glass, paper, metals and plastics, bio-waste.

It is also worth noting that the ordinance mentions bags in which waste should be selectively collected, but only the bio-waste fraction and the metals and plastics fractions, with the purpose of preventing deterioration in the collection of waste fractions.

The topic of the research work undertaken is “The influence of multimedia on changing students’ messages about general, selective waste segregation”. Inspired by the observation of students’ behaviour when throwing waste to the segregation bins in the building of the KEN Pedagogical University of Krakow at 2 Podchorążych Street, I decided to investigate the issue in question.

In the common areas of the university building such as the hall, corridors or dining hall, waste segregation bins adapted to the generally prevailing rules introduced by the Ministry of the Environment of 2017 on selective waste

segregation are available. The undergraduate and postgraduate students, despite the signed bins, were not able to segregate waste properly. It was very common to find plastic packaging in the paper bins, and beverage cans ended up in other bins instead of metals and plastics. The interest in the topic sparked a desire to search for links between the state of the natural environment and conditions affecting the quality of human life.

Multimedia plays an important role in the process of acquiring knowledge and learning. They make use of a variety of modern tools that make it easier to remember new information and consolidate what has already been learned, which I decided to use in my research work.

Method

The research used two main objectives:

1. What is the level of students' knowledge about general waste segregation?
2. What is the impact of multimedia on changing students' messages about general waste segregation?

The method used in the research was a diagnostic survey, and a questionnaire was chosen as the technique. The target group for the research was supposed to be journalism students at the KEN Pedagogical University in Krakow. However, due to negligible interest in the research, the research group was extended to students of various faculties and universities located in Poland.

The following hypotheses were planned:

1. Students at Polish universities have little knowledge of waste segregation in general.
2. The multimedia e-book developed will increase students' knowledge of general waste segregation.
- 3) Students will increase their knowledge of general waste segregation after receiving the e-book and reading it.
4. Survey 2. (posttest) will show that multimedia sources help to assimilate knowledge on general waste segregation.

In order to be able to test the students' knowledge of general separate waste fraction segregation, Questionnaire 1 was created, which included a space for entering an e-mail address - needed to send the developed multimedia e-book - and a nickname, which would be used to compare the answers before and after reading the e-book. (pretest).

The survey questionnaire was divided into a short metric with 4 questions. This was followed by 5 questions covering the scope of waste segregation bins.

The third section with 10 questions covered general waste segregation and recycling knowledge.

After receiving the feedback questionnaires, respondents received the following link <https://read.bookcreator.com/r2wrFWvfe3WoxgftbmlCqYhbRn1/ozwkYR0bT0WXHpDbJRxmfg>. The hyperlink leads to a multimedia e-book I developed with the following resources: Regulation of the Minister of the Environment of 29 December 2016 on the detailed method of selective collection of selected waste fractions, 3 games on the topic of waste segregation, 4 videos, QR codes, iconographies, photos, hyperlinks, articles.

After reading the multimedia e-book, respondents were asked to complete questionnaire 2, which asked about the impact of the increase in resident students' messages after the multimedia e-book was sent on general waste segregation. (posttest)

The questionnaire included: the question, Have you read the e-book? The next section contained 10 questions about the reception of the e-book, questions were asked about the correctness of the choice of materials, the visuality, the learning aid. The fourth section replicated the questions from survey 1 about recycling bins and general waste and recycling.

The questions were juxtaposed with each other for the opportunity to compare and draw conclusions as to what knowledge the students have about waste segregation. This form of comparison was used due to the fact that 122 respondents took part in the pretest and only 36 in the posttest.

Results

By analysing the results, it can be used to conclude that the research objectives and putative hypotheses have been confirmed and realised. Between the pretest and posttest, it is noticeable that there was a 6.5% increase in the declaration of waste segregation by students of different faculties from different universities in Poland. (Fig. 1)

Surveys with the theme of waste separation were complemented by questions on aluminium and glass recycling. (Fig. 2 and 3)

Do you separate your rubbish?

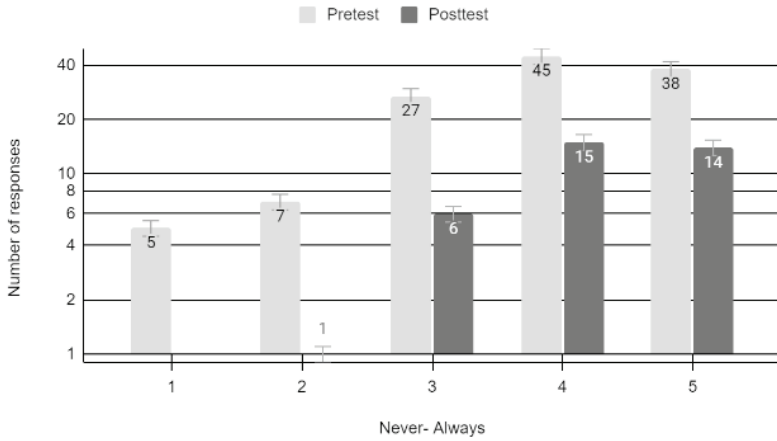


Figure 1. Do you separate your rubbish?

Is aluminium 100% recyclable?

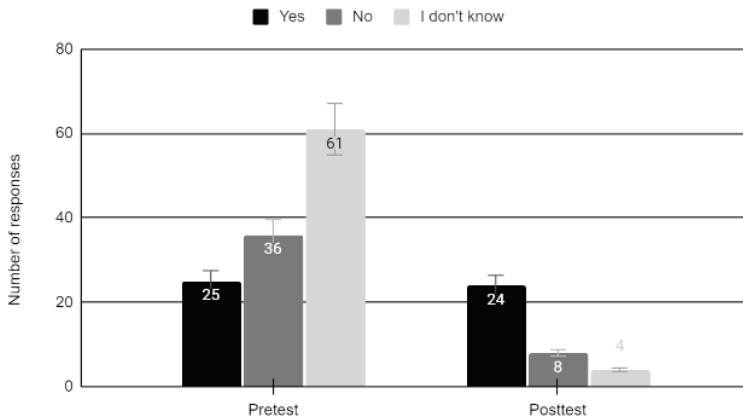


Figure 2. Is aluminium 100% recyclable?

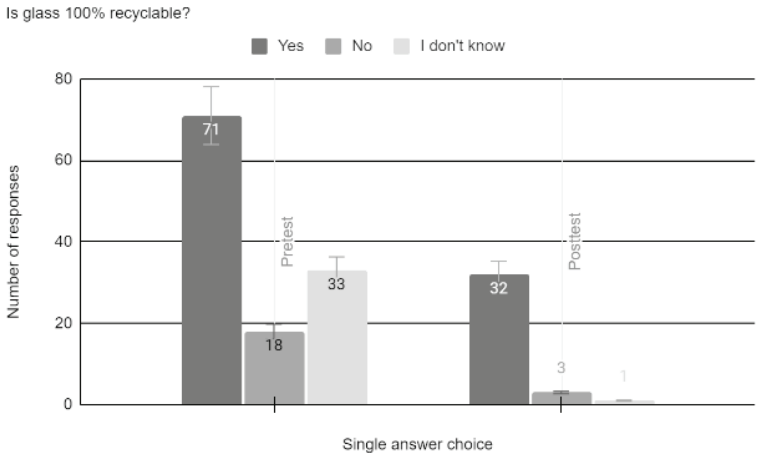


Figure 3. Is glass 100% recyclable?

From the results, it can be concluded that by reading the e-book, the students have acquired knowledge on the subject. In addition, it was asked where Polish students most often put their old clothes. A comforting result of this is that 59% of the respondents give a second life to their clothes by selling them or 66.4% declare that they give their clothes to special bins to help the needy. (Fig. 4)

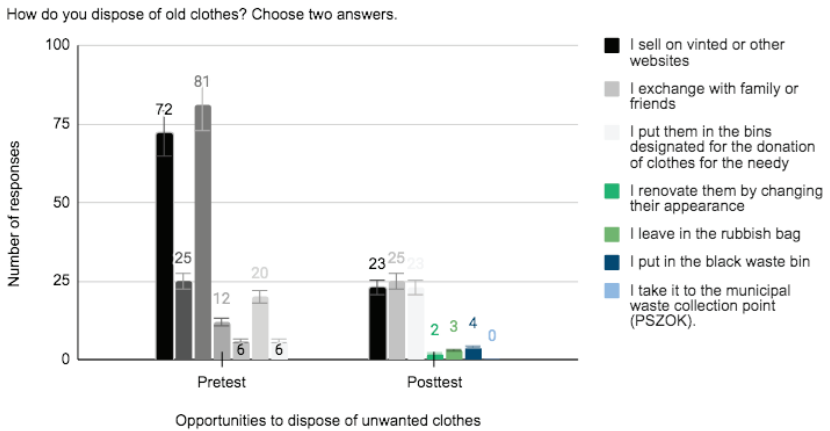


Figure 4. How do you dispose of old clothes? Choose two answers.

The e-book was positively evaluated by the students who consulted it. As many as 86.1% of the students indicated that they had acquired new information thanks to it, (Fig. 5) and 80.5% of them would recommend it to someone else for information on selective waste separation. (Fig. 6)

Do you think you learned new information through the multimedia e-book?

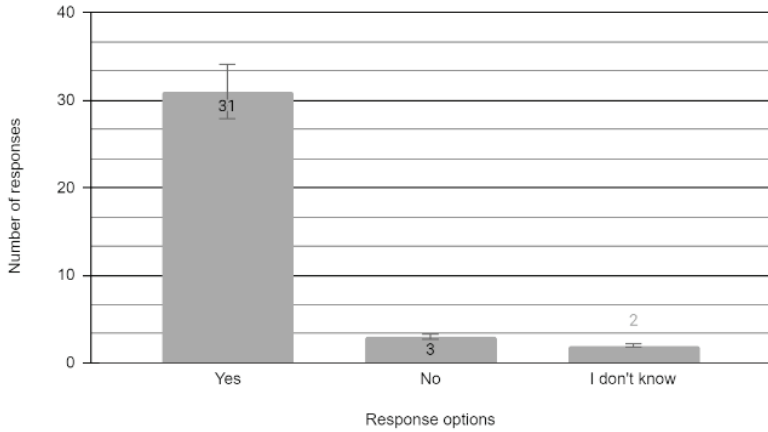


Figure 5 Do you think you learned new information through the multimedia e-book?

Which element in the multimedia e-book did you like best?

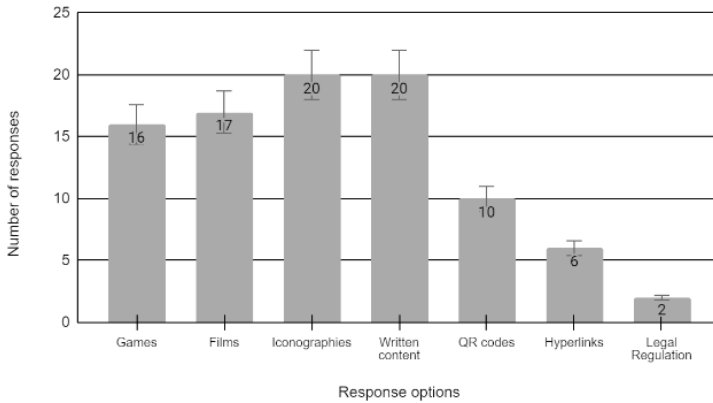


Figure 6 Would you recommend an e-book to someone on the topic of acquiring knowledge about waste separation?

Students chose iconography and written content as the best form of communication (Fig. 7)

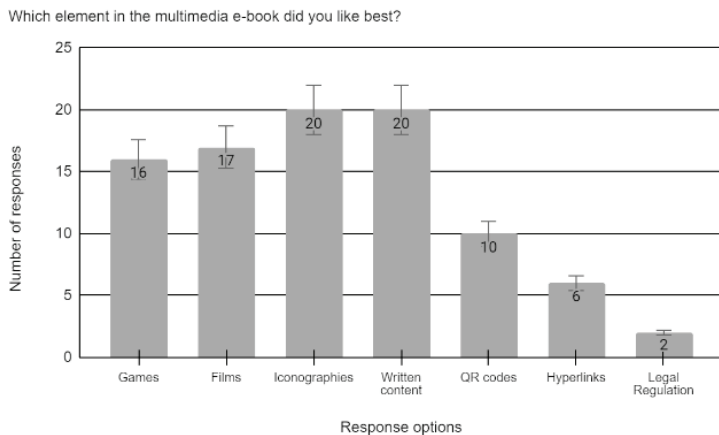


Figure 7. Which element in the multimedia e-book did you like best?

Respondents (97.2%) indicated that they saw the potential in acquiring knowledge through multimedia e-books (Fig. 8).

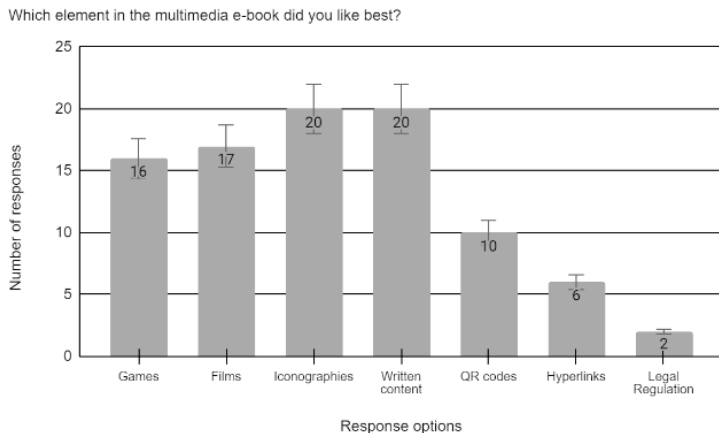


Figure 8. Do you think learning through a multimedia e-book has potential?

In order to improve and enrich the e-book, it is important to apply the suggestions indicated by the respondents so that it is adapted to the expectations and needs of the students. Students have little knowledge of selective waste separation. The multimedia e-book has broadened their knowledge. The rate of positive survey responses increased with the post-test.

Conclusions and implications

Correct waste separation is an important aspect to improve the quality of life. Selective waste separation is also included in the Sustainable Development Goals, Agenda 2030.

Despite the fact that the ordinance on selective waste segregation has been respected in life for 6 years, students have problems with correct waste segregation. It is possible to apply the statement that students of Polish universities are able to master knowledge and find application in practice.

In summary, the students answered the questions in the first survey (pretest) in fairly large numbers (122 responses). They found it very difficult to complete the second survey (posttest) with 36 responses. It is assumed that the impact on the low response rate in the second survey was due to the duration of the survey, the complexity and the high involvement on the part of the student. The fact that the surveys were interrupted for the duration of holidays and long weekends is also taken into account.

The reception of the persevering students was positive, as indicated by comments posted to the posttest that they had never taken part in this type of research. Some of the respondents indicated that the e-book and the survey form did not contain information on: the segregation of fiscal receipts or segregation in single-family dwellings. Students' interest in the topic of waste segregation was recognised. The comments made in the survey forms indicate that the research should be continued and expanded.

It is inferred that students show a desire to increase their knowledge in environmental behaviour. One case was noted in which a respondent would not recommend the e-book to a person who wants to increase knowledge on selective waste segregation. Despite the explanation and outlining of the research topic, the development of a knowledge-rich e-book and educational games, the student rebuffed the information received and recognised it as wrong.

All student comments were listened to and understood. Through their expression, it can be summarised that the guidance stems from the students' involvement and the necessity to address environmental topics in education.

Ethics Statement

The ethics committee confirmed to the corresponding author that this research did not require ethics approval because of the full anonymization of the publicly available data and because the data are not sensitive.

Conflicts of Interest

The authors declare no conflict of interest.

References

Dz.U. 2017 item 19, paragraph 8. Downloaded from <https://isap.sejm.gov.pl/isap.nsf/download.xsp/WDU20170000019/O/D20170019.pdf>

Aleksandra Rozbicka, Małgorzata Nodzyńska - Moroń

*Department of Politics and Social Research, Institute of Journalism and
International Relations, Pedagogical University*

aleksandra.rozbicka@student.up.krakow.pl, malgorzata.nodzynska-moron@up.krakow.pl

Formative assessment supported by the “Digilib” digital library

Ivana Sotáková, Mária Ganajová, Hana Čtrnáctová

[DOI 10.24917/9788368020403.6](https://doi.org/10.24917/9788368020403.6)

Abstract

Within the VEGA No. 1/0265/17 and KEGA No. 004UPJŠ-4/2020 research projects, databases of formative assessment (FA) tools addressing the selected topics taught in the 2nd stage primary school science, mathematics, and informatics have been created. The FA tools that we have developed are available in the “Digilib” digital library hosted on the server <https://digilib.fri.uniza.sk/> equipped with an SSL certificate. Digilib allows for the creation and storing of FA tools (forms) such as the self-assessment card, prediction card, or Frayer model, which can be assigned to students thus providing both them and teachers with real-time feedback. Currently, 8 primary schools, 16 teachers, and 46 classes (grades 5 to 9) with a total of 846 students are registered in the digital library. Semi-structured interviews were conducted to collect teachers’ and students’ opinions on the digital library. The analysis of their answers showed numerous advantages for both teachers and students, e.g., easy and simple interface, quick feedback about students’ current state of knowledge, automated creation of complex overviews of students’ answers and their archiving. The feedback supplied helps students develop objective self-assessment, fill in the gaps, and modify their misconceptions in learning.

Key words

formative assessment, formative assessment tools, digital library, semi-structured interview, teacher opinions

Introduction

Formative assessment (FA) is a planned and ongoing process in which both teachers and students take part. Its goal is to accumulate and use the information about the current state of students’ learning with the aim of finding additional areas to help them progress (Assessment Reform Group, 2002). FA helps identify student’s needs and learning difficulties, and adapt further teaching accordingly (OECD/CERI, 2008). FA can be an efficient tool for learners to enhance their learning gains (William, 2010). As various researchers have noted (e.g., Anwar,

2019; Çekiç & Bakla, 2021; Ganajová et al., 2021), FA is a tool that promotes deeper learning. It helps shape the teaching and learning processes, attain instructional goals, and therefore makes a positive impact on student grades obtained as a result of summative assessment (Tsulaia & Adamia, 2020).

The outcome of the research into formative assessment and computer-assisted assessment is digital formative assessment (DFA), which is also referred to as “online formative assessment” or “web-based formative assessment” (McLaughlin & Yan, 2017). There are several popular DFA tools, such as Socrative, Plickers, Kahoot, Google Forms, Quizizz, Nearpod, and Formative (GoFormative). Similarly, Kahoot, Socrative, Google Forms, Nearpod, Plickers, Mentimeter, and Quizizz were the most researched DFA tools (Çekiç & Bakla, 2021).

Several studies have confirmed that DFA tools help significantly increase students’ achievement and motivation (e.g., Bhagat & Spector, 2017; Elmahdi et al., 2018; Faber et al., 2017; Koedinger et al., 2010; McLaughlin & Yan, 2017; Sheard et al., 2012). These tools allow teachers to receive immediate (real-time) feedback on their students’ current state of knowledge and figure out what steps need to be taken to facilitate further learning, thus making individualised teaching easier (Looney, 2019; Robertson et al., 2019; Walter et al., 2010). Besides the improved performance observed in low-performing students, DFA tools can also contribute to enhanced performance of high performing students (Faber et al., 2017). According to Elmahdi et al. (2018), using DFA tools to assess the gaps in knowledge and skills is an interesting and useful method. DFA tools increase student levels of engagement (Wang & Tahir, 2020). At the same time, they are proving to be efficient tools to help teachers improve their methods and forms of teaching (OECD, 2015; Wang & Tahir, 2020).

In Slovakia, a systemic step towards the implementation of FA in teaching still has not been taken. In the Slovak educational system, summative assessment prevails. Primary school teachers prefer summative assessment tools to formative ones. As the most frequent reason, they stated lack of familiarity with formative assessment tools and their use (Orosová & Sotáková, 2021). In 2017–2022, the implementation of FA in teaching at primary and high schools was supported by the VEGA No. 1/0265/17 “Formative Assessment in Natural Sciences, Mathematics and Informatics” and KEGA No. 004UPJŠ-4/2020 “Creation, Implementation, and Verification of the Effectiveness of Digital Library with the Formative Assessment Tools for the Natural Sciences, Mathematics and Informatics at the Primary School” research projects. The concept of formative assessment, its tools, and strategies have been defined and explained in the publication entitled *Implementation of Formative Assessment in Teaching Science, Mathematics, and Informatics* by Ganajová et al. (2022). In addition, this publication summarizes the achieved results of the project KEGA No. 004UPJŠ-4/2020.

“Digilib” – A Digital Library of Formative Assessment Tools for Science, Mathematics and Informatics at Primary Schools

The main goal of the KEGA No. 004UPJŠ-4/2020 project was to develop a digital FA library, implement it, verify its efficiency, and finalise it. This library supplies tools for the selected thematic units pertaining to science, mathematics, and informatics as taught at primary schools.

In terms of the project goals, 10 different FA tools focused on learning support were selected to develop students' conceptual understanding as well as the selected scientific competences (assumptions, inferences, conclusions, and generalisations) as well as promoting motivation, cooperation, and communication. The selected FA tools were divided into two categories: objective (cognitive) and subjective (metacognitive) (Ganajová et al., 2022). Based on the objective (cognitive) FA tools, the current state of learning is identified in students. These tools include the prediction (before and after) card, conclusion drawing card, Frayer model, and concepts-facts-examples. Subjective (metacognitive) FA tools are based on students' subjective assessment of their own learning process and its results. These tools include the self-assessment card, K-W-L method, card mapping one's own learning process, and different alternative exit cards such as the 3-2-1 card, minute card, and short summary.

In cooperation among the project research team, experts in subject didactics from the Faculty of Science at Pavol Jozef Šafárik University in Košice, and primary school teachers, FA tool databases were created for the selected thematic units/topics in science (biology, chemistry, physics), mathematics, and informatics as taught at primary schools. Subsequently, they were pilot tested, verified, and optimised. The FA tools were created in accordance with the content and performance standards for specific academic subjects pursuant to the State Educational Programme for the second stage of primary schools (SEP, 2014). The total of 36 databases containing 774 FA tools were created (Table 1).

Table 1. The selected thematic units/topics in science, mathematics, and informatics as taught at primary schools for which FA tool databases were created

Thematic unit/Topic					
Academic subject	5th grade	6th grade	7th grade	8th grade	9th grade
BIOLOGY	Nature and Life, Societies of Organisms	Life with Humans and in Their Settlements	Human Body	Basic Life Processes in Organisms, Heredity and Variability in Organisms, The Living Environment of Organisms and Humans	Exploring Inanimate Nature
CHEMISTRY			Substances and their Properties, Substance Transformations	Important Chemical Elements and Compounds	Carbon Compounds
PHYSICS				Bodies in Motion, Work, Power, and Energy, Magnetic and Electrical Phenomena, Electric Circuit	
MATHEMATICS	Plane Symmetry (axial and centric)	Mathematical Operations with Natural Numbers, Triangle, Congruence of Triangles	Fractions, Percentages, Cuboid and Cube, Ratio, Direct and Indirect Proportion, Combinatorics	Positive and Negative Integers, Variable, Expression, Parallelogram, Trapezoid (perimeter and area), Circle, Probability, Statistics, Triangles	Powers and Square Roots, Linear Equations and Inequalities, Similarity of Triangles, Graphical Representation of Dependence
INFORMATICS	Software and Hardware (basic concepts); Communication Software and Hardware – Input and Output Devices, Representation and Tools – working with text, presentations, tables, and cooperation – Working with Communication Tools – e-mail, Internet search, Software and Hardware – working with files and folders, computer and additional devices	Software and Hardware – Input and Output Devices, Representation and Tools – working with text, presentations, tables	Software and Hardware – PC memory; Information Society – safety and risks, Viruses and Antivirus Software, Using the Internet Safely, Communication and Cooperation – working with websites	Representation and Tools – working with tables, multimedia, dealing with viruses and spyware; Information Society – safety and risks	Representation and Tools – raster graphic, problem-solving algorithms – Introduction to the Python Programming Language

The FA tool databases for individual academic subjects are available in the “Digilib” digital library. “Digilib” was developed as a web application hosted at the faculty web server <https://digilib.fri.uniza.sk/> and equipped with an SSL certificate. It consists of sections such as user, year, class, and topic management, forms and their evaluation, etc. The application employs user roles (administrator, coordinator, teacher, student). The FA tools are referred to as “forms” in it. “Digilib” allows teachers to create and save their own FA tools (forms), which can be assigned to students to collect information about their understanding of the subject matter, i.e., to receive real-time feedback. Moreover, a teacher can provide individual commentary on each student’s answers. For more details, see Figures 1–3. All figures are in the language of the application. This application can also be expanded by adding new types of forms. A user manual was created for the teachers to learn how to use the digital library.

Vytváranie sebahodnotiacej

Predmet: Chémia

Ročník: 8

Téma: Vodík

Zvoliť

Otázky

B I U O₂ $\frac{g}{dm^3}$ () ω Ω

K CH ↻ ?

Správa:

Viem napísať rovnicu chemickej reakcie HCl a Zn.

Viem napísať rovnicu chemickej reakcie HCl a Zn.

Pridať otázku Načítať otázky

- Kontrolné zoznamy
- Formuláre pre metakogníciu
- Tabuľky pre použitie stratégie K-W-L
- Fruyerovej model so zadaným pojmom
- Fruyerovej model s dopĺňaním pojmu
- Minútové lístky
- Lístky pri odchode
- Hybridné formuláre

Figure 1. Creating a specific self-assessment card

Moje sebahodnotiace karty 🔍

Predmet: Ročník:

Zobraz záznamov Hľadať:

Predmet ↑	Ročník ↑	Téma							
Chémia	8	Vodík	Otázky	Priradiť	Študenti	Výsledky	Porovnať	Poznámky	✕
Chémia	8	Kyslík	Otázky	Priradiť	Študenti	Výsledky	Porovnať	Poznámky	✕
Chémia	8	Názvoslovie halogenidov	Otázky	Priradiť	Študenti	Výsledky	Porovnať	Poznámky	✕
Chémia	8	Významné halogenidy	Otázky	Priradiť	Študenti	Výsledky	Porovnať	Poznámky	✕

Figure 2. My self-assessment card type forms

Otázka ↑↓	Odpoveď
Poznám spôsob zapisovania chemických reakcií.	Samostatne
Viem definovať chemické reakcie.	S pomocou
Viem pomenovať látky, ktoré vznikajú pri chemickej reakcii.	Samostatne
Viem pomenovať látky, ktoré vstupujú do chemickej reakcie.	S pomocou
Viem uviesť 3 príklady chemických reakcií,	S pomocou

Figure 3. Results of a student's active attempt to fill in the self-assessment card

Methods

In the 2022/2023 school year, 8 primary schools, 16 teachers, 46 classes (grades 5 to 9), and 846 students were registered in the “Digilib” digital library. The selection of schools was deliberate and guided by the criteria explained below. Firstly, schools with a positive attitude to innovation managed by headteachers that support the digital transformation of education and active learning were

selected. The second criterion was teachers' active participation in the VEGA No. 1/0265/17 and KEGA No. 004UPJŠ-4/2020 research projects and their interest in the active implementation of FA in teaching. Teachers were allowed to freely choose FA tools for science (biology, physics, chemistry), mathematics, and informatics and modify them for the purpose of their own teaching needs. Teachers implemented the FA tools in teaching in the printed and/or digital form using "Digilib". Regular instruction seminars were organised for the teachers to share their experience with the implementation of FA in the teaching process and consultations were also provided.

The opinions and attitudes of teachers and students to FA and the use of the "Digilib" digital library during lessons were collected by a semi-structured interview. A semi-structured interview is a qualitative research method (Hendl, 2005). Semi-structured interviews were divided into 4 areas.

Interview with a teacher – structure

Introduction (school, academic subjects taught, years, classes).

Implementation of the FA tools in teaching (FA tool types, frequency of use, form of implementation).

Positive aspects of the "Digilib" digital library implementation in teaching

Negative aspects of the "Digilib" digital library implementation in teaching

Interview with a student – structure

Introduction (school, year, class).

Which FA tool provides the best feedback about their level of understanding the new knowledge?

Evaluation of work in the "Digilib" digital library environment.

A comparison of FA tools filled in the printed vs. digital form.

Teachers and students participated in the semi-structured interviews voluntarily. Ethical principles were strictly adhered to. The participants received information as well as the informed consent form in advance. The information about students was obtained from their teachers based on the written consent provided by their parents (legal representatives).

Results

In this part, an evaluation of the semi-structured interviews performed at a selected primary school in Košice as part of this case study will be presented. The respective teacher implemented the FA tools and used the “Digilib” library for teaching chemistry in a 7th grade class attended by 14 students. The overall academic performance in this class was average and 5 students came from a socially disadvantaging environment.

Teacher

Implementation of the FA tools in teaching (FA tool types, frequency of use, form of implementation)

During two months (February – March 2023), students were asked to work with 10 FA tools addressing the “Substance Transformations” topic. 4 self-assessment cards, 4 prediction cards, and 1 checklist were used. Students filled in 5 FA tool forms in the printed form and 5 tools in the digital form via “Digilib”.

Positive aspects of the “Digilib” digital library implementation in teaching according to the teacher:

Accessibility of various ready-made FA tools.

A wide range of output options – details of student answers, summaries of the individual questions/assignments, assessment by class, etc.

Student performance assessment in the form of tables and charts. The possibility to compare the results achieved by parallel classes.

All students’ outputs (filled in FA tools) are in a single database, which allows the teacher to follow their learning progress.

Development of digital skills in both teachers and students.

The student can revise their answers and improve their learning.

The teacher can comment on the answers to provide feedback.

Negative aspects of the “Digilib” digital library implementation in teaching according to the teacher:

Inability to correct/modify a specific FA tool and change its format.

Necessity of Internet connection to fill in the FA tools.

Too many students in the class.

Missing technical equipment – notebook or tablets for students.

Students

Which FA tool provides the best feedback about their level of understanding the new knowledge?

Students liked the prediction card the most – it allowed them to formulate their own assumptions and consider different statements. The digital checklist was also very popular among students – it allowed them to provide yes/no answers to verify their knowledge and improve it.

Evaluation of work in the “Digilib” digital library environment. A comparison of FA tools filled in the printed vs. digital form.

It was interesting, different than in other lessons – I enjoyed when I realized what I did not know and should learn it.

I was not graded so I was not afraid even when I picked the wrong answer. I liked that I could test myself to see whether I understand the subject matter.

Miss Teacher did not have to print papers, so it was more ecological, and we also improved in using technology.

It is easier and quicker to fill than a paper.

It showed me the results right after I fill in the card, so we saved a lot of time.

The teacher claimed that students liked the FA tools, they found it meaningful, and it helped them improve their learning habits. Students preferred the digital form using “Digilib” from the printed form. Based on the experience and knowledge gained during the implementation of FA tools in teaching, this teacher plans to continue using them in the next school year and also in other academic subjects besides chemistry.

Conclusions and Implications

The FA tool databases were created for the selected thematic units/topics in science (biology, physics, chemistry), mathematics, and informatics for primary schools. In future, these could be implemented in teaching at the secondary stage of primary schools. Teachers can use FA tools to provide students with feedback and help them improve their learning process. The “Digilib” digital library can make the implementation of FA tools in teaching more efficient. Apart from other DFA tools (e.g., Kahoot!, Socrative, Google Forms), “Digilib” offers FA tools as ready-made forms for various academic subjects. Moreover, teachers can also create their own FA tools using the pre-formatted templates. When the FA tools are created and assigned to students, it provides both teachers and students with extensive feedback on student answers including explanations as to why some answers were incorrect and how students can improve. It creates new opportunities for teachers to perform diagnostics and achieve the educational

goals. When students learn to perform (self)assessment, it helps them develop critical thinking skills as well as correct their own learning and attitudes.

Based on the teachers' (user) feedback, the "Digilib" functionalities will be further improved and expanded (immediacy, elaborative feedback from the user/teacher, personalized feedback for the student, reusability, accessibility, interface design, interaction). Moreover, the current KEGA No. 001UPJŠ-4/2023 "Implementation of formative assessment in primary school teaching with the focus on the digital form" research project aims to create more FA tool databases for social science subjects (Slovak Language, English Language, German Language, History) and incorporate them in the existing digital library. Further research aims to identify the influence of Digilib-supported FA tools on the development of conceptual understanding, self-reflection competence in students as well as the opinions and attitudes of teachers, students, and their parents to FA. The findings can be used in the curricular reform of primary education, which is currently being implemented in Slovakia, specifically in educational system digitalisation and student assessment in the individual education cycles and areas to satisfy the 21st century educational needs.

Acknowledgements

This paper has been supported by the KEGA No. 001UPJŠ-4/2023 "Implementation of formative assessment in primary school teaching with the focus on the digital form" grant.

Ethics Statement

The ethics committee confirmed to the corresponding author that this research did not require ethics approval because of the full anonymization of the publicly available data and because the data are not sensitive.

Conflicts of Interest

The authors declare no conflict of interest.

References

- Anwar, S. (2019). Formative assessment tool for active learning. *European Journal of Biomedical and Pharmaceutical Sciences*, 6(1), 480-485.
- Assessment Reform Group. (2002). *Assessment for Learning: 10 principles. Research-based principles to guide classroom practice assessment for*

- learning. Assessment Reform Group. https://www.hkeaa.edu.hk/doclibrary/sba/hkdse/eng_dvd/doc/Afl_principles.pdf
- Bhagat, K. K., & Spector, J. M. (2017). Formative assessment in complex problem-solving domains: The emerging role of assessment technologies. *Journal of Educational Technology & Society*, 20(4), 312-317. <https://www.jstor.org/stable/26229226>
- Çekiç, A., & Bakla, A. (2021). A review of digital formative assessment tools: Features and future directions. *International Online Journal of Education and Teaching*, 8(3). 1459-1485.
- Elmahdi, I., Al-Hattami, A., & Fawzi, H. (2018). Using technology for formative assessment to improve students' learning. *Turkish Online Journal of Educational Technology*, 17(2), 182-188.
- Faber, J. M., Luyten, H., & Visscher, A. J. (2017). The effects of a digital formative assessment tool on mathematics achievement and student motivation: Results of a randomized experiment. *Computers & Education*, 106, 83-96. <https://doi.org/10.1016/j.compedu.2016.12.001>
- Ganajová, M., Guniš, J., Ješková, Z., Kireš, M., Laufková, V., Lešková, A., Lukáč, S., Orosová, R., Sotáková, I., Szarka, K., & Šnajder, Ľ. (2022). *Formatívne hodnotenie a jeho implementácia do výučby prírodných vied, matematiky a informatiky [Implementation of Formative Assessment in Teaching Science, Mathematics, and Informatics]*. Wolters Kluwer.
- Ganajová, M., Sotáková, I., Lukáč, S., Ješková, Z., Jurková, V., & Orosová, R. (2021). Formative assessment as a tool to enhance the development of inquiry skills in science education. *Journal of Baltic Science Education*, 20(2), 204-222. <https://doi.org/10.33225/jbse/21.20.204>
- Hendl, J. (2005). *Kvalitatívni výzkum – základní metody a aplikace [Qualitative research: Basic methods and applications]*. Portál.
- Koedinger, K. R., McLaughlin, E. A., & Heffernan, N. T. (2010). A quasi-experimental evaluation of an on-line formative assessment and tutoring system. *Journal of Educational Computing Research*, 43(4), 489e510. <https://doi.org/10.2190/EC.43.4.d>
- Looney, J. (2019). Digital formative assessment: A review of the literature. European Commission. <http://www.eun.org/documents/411753/817341/Assessment%40Learning+Literature+Review/be02d527-8c2f-45e3-9f75-2c5cd596261d>
- McLaughlin, T., & Yan, Z. (2017). Diverse delivery methods and strong psychological benefits: A review of online formative assessment. *Journal of Computer Assisted Learning*, 33(6), 562-574. <https://doi.org/10.1111/jcal.12200>
- OECD/CERI. (2008). *Assessment for learning: Formative assessment*. OECD/CERI Publishing. <http://www.oecd.org/site/educeri21st/40600533.pdf>
- OECD. (2015). *Students, computers and learning: Making the connection, PISA*.

- OECD Publishing. <http://dx.doi.org/10.1787/9789264239555-en>
- Orosová, R., & Sotáková, I. (2021). Monitoring the use of formative assessment tools in science subjects at primary schools in Slovakia. In L. Gómez Chova, A. López Martínez, & I. Candel Torres (Eds.), *INTED2021: 15th International Technology, Education and Development Conference: Conference Proceedings* (pp. 4284-4293). IATED. <https://doi.org/10.21125/inted.2021.0871>
- Robertson, S. N., Humphrey, S. M., & Steele, J. P. (2019). Using technology tools for formative assessments. *Journal of Educators Online*, 16(2), 1-10. <https://doi.org/10.9743/JEO.2019.16.2.11>
- Sheard, M. K., Chambers, B., & Elliott, L. (2012). Effects of technology-enhanced formative assessment on achievement in primary grammar. Institute for Effective Education. https://eprints.whiterose.ac.uk/75089/1/QfLGrammarReport_Sept2012.pdf
- ŠPÚ [SEP]. (2014). *Inovovaný štátny vzdelávací program pre 2. stupeň ZŠ [The National Education Programme for Lower Secondary Education]*. <https://www.statpedu.sk/sk/svp/inovovany-statny-vzdelavaci-program/inovovany-svp-2.stupen-zs/>
- Tsulaia, N., & Adamia, Z. (2020). Formative assessment tools for higher education learning environment. *Scientific Journal "WEST-EAST"*, 3(1), 86-93. <https://doi.org/10.33739/2587-5434-2020-3-1-86-93>
- Wang, A. I., & Tahir R. (2020). The effect of using Kahoot! for learning: A literature review. *Computers & Education*, 149, 103818. <https://doi.org/10.1016/j.compedu.2020.103818>
- Walter, D., Way, R. P., Dolan, R. P., & Nichols, P. (2010). Psychometric challenges and opportunities in implementing formative assessment. In H. L. Andrade, & G. J. Cizek (Eds.), *Handbook of formative assessment* (pp. 297-315). Taylor & Francis.
- William, D. (2010). An integrative summary of the research literature and implications for a new theory of formative assessment. In H. L. Andrade, & G. J. Cizek (Eds.), *Handbook of formative assessment* (pp. 18-40). Taylor & Francis.

Ivana Sotáková¹, Mária Ganajová¹, Hana Čtrnáctová²

¹ *Department of Didactics of Chemistry, Faculty of Science, Pavol Jozef Šafárik University in Košice*

² *Department of Chemistry Education, Faculty of Science, Charles University,*

ivana.sotakova@upjs.sk, maria.ganajova@upjs.sk, hana.ctrnactova@natur.cuni.cz

The use of 3D printing technology in the opinion of primary school students

Kinga Wierzbicka, Alicja Walosik

[DOI 10.24917/9788368020403.7](https://doi.org/10.24917/9788368020403.7)

Abstract

The growing accessibility of 3D printing technology has led to reduced prices of devices and materials, making it easier for schools to purchase equipment through initiatives like the Future Laboratories program. This development has created an opportunity for a more innovative approach to teaching using 3D printing. Specifically, the application of 3D printing and 3D pens can greatly enhance the learning experience in subjects such as science, mathematics, and technology. To evaluate the extent to which this technology is utilized in primary schools, a research study was conducted using a diagnostic survey method involving teachers and students. Separate questionnaires were designed for both groups. The participants were also asked about the skills they developed through working with 3D printing and provided suggestions for topics where 3D pens and printers would be beneficial. The survey findings revealed that in previous years, neither students nor teachers had the opportunity to utilize 3D printing or 3D pens. Currently, the implementation of 3D printing technology in schools remains at a significantly low level, as indicated by the research. The detailed results of the study are presented in the report.

Keywords

3D printing, primary school education

Introduction

Scientific and technological progress is particularly visible in various branches of the economy, but also in education. A 21st century student is a person who is looking for new, interesting solutions, for whom there are currently no barriers to using modern devices, technologies or applications. A combination of equipment, technology and applications can be used in classes with a 3D printer. The use of 3D printing technology at school increases students' practical skills in the design process, interest in science and understanding of three-dimensional space. Working in graphic programs and 3D modeling is the development of spatial thinking. The introduction of 3D printing into the teaching process promotes the

development of thinking and develops student creativity and activity. 3D printing is becoming a key challenge for education.

Teaching is a field that is constantly developing. This development involves, in particular, developing teaching methods that can be used to improve the education process of pupils and students, as well as the use of new technological possibilities. In this context, the basic task of the teacher is to adapt to the changes that occur in teaching - especially the implementation of new teaching methods and the use of modern devices during learning. An example of devices that have recently been used in the teaching process is a 3D printer. Using it, it is possible to create spatial objects based on a computer model. 3D printing technology is compatible with the core curriculum (Regulation of the Ministry of National Education of July 14, 2017, Journal of Laws of 2017, item 356) and supports the educational process. The implementation of this innovative technique allows students at all stages of education to develop new talents - using knowledge, creativity and design skills.

Examples of the use of 3D printing

nature / biology:

printout of a selected organ, e.g. the inside of an ear or an eye,

models of the systems that make up the human body,

floors of vegetation in the mountains

biology/chemistry:

models of teeth and observation of their structure in terms of function,

construction of the DNA helix and the use of knowledge about the correct nucleotide sequence,

models of selected elements,

model of the atom and its nucleus.

A 3D printer at school is an innovative support for the teaching process, giving access to many educational models - especially in the natural sciences (Jaworska, Podsiadło, 2019). Working with 3D printing gives you the opportunity to design and create your own models, e.g. of skeletons and individual human organs. 3D printing is becoming more and more cheaper and more popular among young people, so it is worth using their interests and inspirations to print various objects that can be used to make biology, chemistry, physics or geography lessons more attractive. Humanity has always been fascinated by dinosaurs, which have now become an inspiration for 3D printing, which can be used in various age groups with varying degrees of difficulty. 3D modeling with printing gives students the opportunity to work in groups to jointly create and construct models, geographical models or educational installations in physics. In physics lessons,

the atomic models used will no longer be abstract, and the construction of simple machines will help understand the meaning of physical concepts. The world of modern technologies teaches students to face challenges and solve problems using creativity and ingenuity. 3D printing can be used in every classroom to make the teaching process more attractive. Even working with the youngest can bring fantastic results when creating seasonal decorations.

Collaboratively designing a model, selecting it, and even correcting errors combines problem-solving skills with creativity and innovation. 3D printing allows you to produce very complex shapes and sizes that can be used in biology lessons. Creating a human skeleton or anatomical models will provide students with knowledge they will remember for a long time. Printed models of organs, cells, tissues and even prostheses trigger the creativity and imagination of young artists, bringing them a lot of satisfaction. Using a 3D printer develops students' sense of technological thinking and at the same time stimulates interest in science and technology. A 3D printer at school can have unlimited uses. The creativity of teachers and students has great potential to be used in education. The teacher, together with the students, can design and print objects that will serve as teaching aids. Learning through contact with a model becomes faster and more effective. The use of printed models will increase student engagement in the lesson (Kęska, 2023).

3D printing plays a huge role in the teaching process because:

- develops problem-solving skills,

- develops creativity,

- teaches a technical approach to many areas of life,

- transforms some of the abstract knowledge from students' books into three-dimensional and real objects.

Teachers and lecturers can print teaching aids, and 3D printers themselves can be tools for learning new skills and developing creativity.

The introduction of 3D printing in lessons has a positive impact on the development of students, stimulating their imagination and perception of reality, which translates into better learning results.

Analytical and mathematical thinking plays an important role and allows us to give dimensions to specific objects.

In addition, 3D modeling develops important skills in science education such as:

- spatial skills, spatial visualization, mental rotation,

- teamwork skills (practicing negotiation skills, exchanging comments, collaborating on projects),

skills related to the practical use of modern technologies

skills related to working on a computer as a tool used in the teaching process.

3D printing lesson in primary school starting with the modeling stage:

stimulates spatial imagination,

allows you to freely improve your projects, thus teaching you self-confidence, acceptance of making mistakes, and teamwork based on the Design Thinking method.

Using Canva templates - mind maps and SWOT analysis, students create various models useful in everyday school reality.

develops critical thinking skills.

Research methods and techniques

The research was carried out using the diagnostic survey method - survey technique. A questionnaire was prepared using the Microsoft Forms tool and then made available to primary school teachers, who were then made available to students. 60 students completed the form. The questionnaire included 10 questions addressed to students, including one open one about the use of 3D printing in the teaching process in primary school.

Research

Research results indicate that as many as 87% of respondents have encountered 3D printing. 52% of the students are eighth-grade students, the remainder are fourth-, fifth-, sixth- and seventh-grade students. The gender proportions are comparable: 52% - girls, 48% - boys.

During the research, question no. 1 required students to assess their level of knowledge of 3D printing. More than half of the respondents (59%) said that they knew what it was about, 28% had good knowledge of the subject, but had no practice.

Lessons in which the student had frequent or very frequent contact with 3D printing technology include: physics, chemistry, mathematics, biology and nature. Less than 10% of respondents indicated that 3D printing was very often used in lessons: computer science, geography, technology and art (Fig. 1).

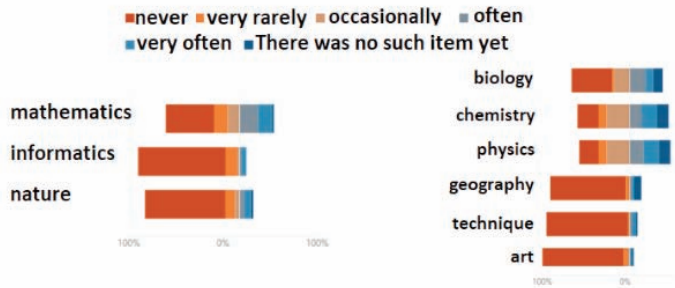


Figure 1. Lessons in which the student was exposed to 3D printing technology

Despite little knowledge and practice in 3D printing, students list its various applications:

During mathematical tasks, e.g. prisms, squares, rectangles, triangles

Mockups

Creating new projects on a given topic

Printing little Jesus Christs during religion classes

For learning how to build a house

Logic puzzles

Printing, for example, parts of an organ and discussing it - biology

A representation of the insides of a frog

Europe map print

Printing computer parts during a computer science lesson

School supplies

As works during art classes

Help with remembering

Developing imagination

E.g. Biology to see the insides of the human body or geography to see a given area up close in a smaller size

Printing things to use in the lesson.

3D printing can be used to create models of class work. This develops creativity and the student can create something of his own

Mathematics calculating area

Animal models.

The respondents commented on the importance of individual statements: the most important were those that concerned increasing the attractiveness of the lesson and those that talked about the development of spatial imagination. The following very important statements were:

increase the attractiveness of classes (50% most important, 9% - very important, 21% - important),

develop spatial imagination (45% most important, 17% - very important, 22% - important),

increase the effectiveness of learning (33% most important, 9% - very important, 16% - important)

develop skills related to the practical use of modern technologies (30% most important, 20% - very important, 22% - important) (Fig. 2A, 2B).

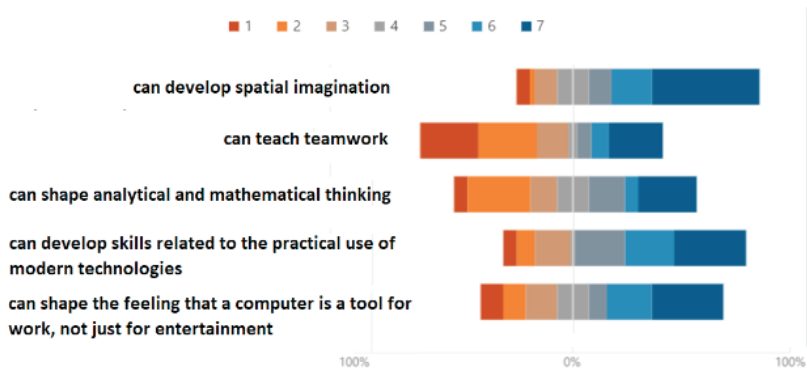


Figure 2A. Significance of statements regarding the use of 3D printing (1 - not important, 7 - very important).

Additionally, students stated that 3D printing:

shapes the feeling that the computer is a tool for work, not just for entertainment,

develops students' creativity,

can teach a technical approach to many areas,

can teach teamwork,

can shape analytical and mathematical thinking,

can illustrate the subject content acquired by students,

can develop skills included in the core curriculum requirements,
can make difficult issues easier to understand.

Respondents stated that 3D printing does not reduce efficiency and motivation

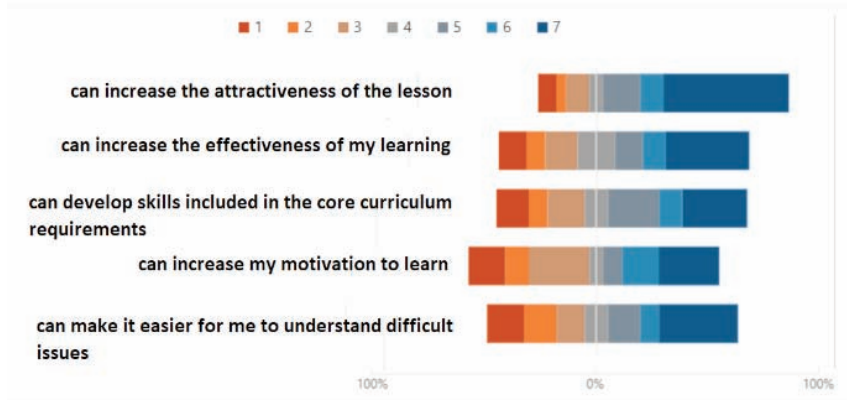


Figure 2B. Significance of statements regarding the use of 3D printing (1 - not important, 7 - very important).

Conclusions

Using a 3D printer develops students' sense of technological thinking and at the same time stimulates interest in science and technology. A 3D printer at school can have unlimited uses. The creativity of teachers and students has great potential to be used in education. The teacher, together with the students, can design and print objects that will serve as teaching aids.

Learning through contact with a model becomes faster and more effective. Printed models of organs, cells, tissues and even prostheses trigger students' creativity and imagination, bringing them a lot of satisfaction. The use of printed models will increase student engagement in the lesson.

Ethics Statement

The ethics committee confirmed to the corresponding author that this research did not require ethics approval because of the full anonymization of the publicly available data and because the data are not sensitive.

Conflicts of Interest

The authors declare no conflict of interest.

References

Jaworska Natalia, Podsiadło Halina, 2019, 3D printing technology as an opportunity for the natural environment, Warsaw University of Technology
Kęska Hubert, 2023, The world of our children. Volume 2. Nature and technology, SQN Publishing House,

Kinga Wierzbicka¹, Alicja Walosik²

¹Małopolska Teacher Training Center in Cracow

²University of Commission of National Education in Cracow

k.wierzbicka@mcdn.edu.pl , alicja.walosik@up.krakow.pl

Contents

<i>Introduction -</i>	5
Věra Ferdiánová, Marek Bukovský, Jakub Poruba - <i>Support training in algorithmization using GeoGebra tools - .</i>	7
Agnieszka Lewandowska, Małgorzata Nodzyńska-Moroń - <i>Student's knowledge regarding air pollution and the role of multimedia in changing attitudes -</i>	17
Małgorzata Nodzyńska-Moroń - <i>Artificial intelligence in the teacher's work -</i>	29
Patrik Pospíšil, Veronika Švandová, Jaromír Literák - <i>Pass rate of students of Chemistry Teaching at final state exam: Case study analysing influences on success rate of students with stress on distance learning during Covid-19 pandemic -</i>	55
Aleksandra Rozbicka, Małgorzata Nodzyńska-Moroń - <i>Impact of multimedia on changing students' knowledge of general selective waste separation -</i>	71
Ivana Sotáková, Mária Ganajová, Hana Čtrnáctová - <i>Formative assessment supported by the "Digilib" digital library -</i>	81
Kinga Wierzbicka, Alicja Walosik - <i>The use of 3D printing technology in the opinion of primary school students -</i>	93

ISBN 978-83-68020-40-3
e-ISBN 978-83-68020-41-0
DOI 10.24917/9788368020403