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PROJECT-BASED AND OTHER STUDENT-ACTIVATION STRATEGIES AND ISSUES IN SCIENCE EDUCATION

XXI.

BOOK OF ABSTRACTS

Dominika Koperová & Martin Rusek (Eds.)

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CONTENTS

SUPPORTING STEAM-BASED TEACHER EDUCATION WITH PROJECT-BASED LEARNING AND THE INTEGRATION OF AUGMENTED/VIRTUAL REALITY AND 3D PRINTING

Zsolt Lavicza

Abstract:

This talk will explore the rapid evolution of 3D-related technologies, presenting versatile platforms for 3D modelling in both electronic and physical formats. Beyond industry applications, the educational potential of 3D modelling is gaining substantial traction. I will introduce studies conducted by the STEAM education research group at the Linz School of Education. These studies introduce AR/VR and 3D printing applications to teacher education globally, examining teachers' perceptions and perspectives on these technologies. It is important to develop educational ecosystems for 3D-based technologies, fostering and evaluating diverse pedagogical approaches for 3D modelling. Our approach motivates students by integrating arts and culture into educational environments, and creating 3D resources for students with disabilities and those from disadvantaged communities. Additionally, we explore strategies to engage girls in STEM studies through 3D modelling. We also aim to empower teachers and students to become innovators and creators using these powerful technologies. Recognizing the need for new theoretical and methodological approaches, we extend our work from mathematics to STEAM through arts and culture. We propose a STEAM+X approach and supplement Design-Based Research (DBR) with User Experience (UX) research methodologies to effectively address the rapid changes in technology development. I will highlight exemplary practices from various countries emphasizing project-based learning practices integrated with emerging technologies.

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PHYSICS CURRICULUM IN UPPER SECONDARY SCHOOLS: WHAT DO LEADING PHYSICISTS AND OTHER STAKEHOLDERS WANT?

Vojtěch Žák

Abstract:

This contribution mainly focuses on the views of leading Czech physicists regarding a physics curriculum for upper secondary schools. It introduces the first and second parts of an effort to define starting points for a new physics curriculum in Czechia and create a new physics textbook for upper secondary schools. In the first part, the study used interviews with 29 leading Czech physicists and identified 56 ideas (categories) they agreed on. Subsequently, a questionnaire was created based on these ideas which was sent to the interviews' participants two years later with the attempt to clarify the relevance and permanence of the ideas. Four core categories—students, physics, context, and math—were identified through a comparison of the relevance of the ideas. The second part of mapped views of three other groups of stakeholders—scientists from other related fields (32), physics teachers from upper secondary schools (539), and physics teacher educators (31)—regarding the physics curricula for upper secondary schools. The results showed there is a strong consensus on what the physics curriculum for upper secondary schools should be, which can be seen as a promising starting point when developing a new physics (or science) curriculum and implementing it in education.

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WHAT WE LEARN ABOUT NATURE FROM FOLK SONGS: ANIMALS AND PLANTS IN OUR ANCESTORS´ LIVES

CO SE DOZVÍME O PŘÍRODĚ Z LIDOVÝCH PÍSNÍ: ZVÍŘATA A ROSTLINY V ŽIVOTĚ NAŠICH PŘEDKŮ

Jana Poupová

Abstract

The article deals with an IBSE activity that enables pupils to reconstruct which animal and plant species our ancestors were acquainted with: Pupils use lyrics of folk songs to compile a list of species. The research interconnects biology to music education, history (the contemporary trend called animal turn) and Czech language. Its main goal is to make pupils familiar with partial steps of scientific research and methodological concepts involved (such as representative sample, data interpretation, etc.). Moreover, the activity draws attention to disciplines on the boundaries of natural and social sciences. The activity is suitable for elementary school pupils, no special equipment is needed.

Key words: Inquiry-based education; Folk song; Animals; Plants

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STRATEGIES FOR THE USE OF CHATGPT BY UNIVERSITY STUDENTS

STRATEGIE POUŽITÍ CHATGPT UNIVERZITNÍMI STUDENTY

Josef Šedlbauer, Jan Činčera, Martin Slavík & Adéla Hartlová

Abstract:

We report on the experience of junior university students (N=25) assigned with the task to work on their seminar essays with the aid of ChatGPT. Most students were novices with this tool, but quickly developed the necessary skills for more or less efficient use of the generative artificial intelligence. Their attitudes towards the tool were almost equally distributed from enthusiastic to indifferent and cautious, with one student refusing on ideological grounds to interact with the artificial intelligence. With the first experience, vast majority of the students declare themselves as adopters of the new technology. We have found some evidence for enhancing the critical thinking competence when using ChatGPT, as well as examples of unquestioned reliance on its outputs. Tendency to personification of the chatbot was apparent. We notice that introduction of generative artificial intelligence to education accelerates the already growing emphasis on personal and research-oriented approach in teaching and learning.

Keywords: ChatGPT; Generative artificial intelligence; Education; Critical thinking

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WHAT CAN WE FIND OUT IN SCHOOL TEXTBOOKS ABOUT CURRENT BIOTECHNOLOGY?

ČO SA DOZVIEME O SÚČASNÝCH BIOTECHNOLÓGIÁCH ZO ŠKOLSKÝCH UČEBNÍC?

Michaela Horniaková & Martin Jáč

Abstract:

The research deals with the content analysis of current biotechnology in teaching materials. Biotechnology is a rapidly changing field. The research allows for a deeper understanding of the content of teaching and learning materials and also contributes to the possibility of assessing whether existing learning materials are relevant, well-structured, and appropriate for the current needs of learners. The content analysis was carried out on 12 textbooks and 7 workbooks for the 8th and 9th grades of lower secondary schools and lower-level grammar schools; 8 textbooks for upper secondary schools and upper-level grammar schools in the Czech Republic. The created categorical system is based on the content analysis carried out by inductive coding. In total, there were 5 main categories, and each category contains subcategories (in brackets). Categories identified in the textbooks were biotechnology (2); genetic engineering (8); genetically modified organisms (4); cloning (5), and breeding (6). Only 1 out of 12 textbooks for lower secondary schools and lower-level grammar schools, contains every category. Three textbooks contain no information about whole area at all. In 3 out of 8 textbooks, for upper secondary schools and upper-level grammar schools, every category is mentioned. At the conference the occurrences of categories, and subcategories will be presented.

Research is supported by GFD_Pdf_2023_06.

Keywords: Education; Biotechnology; Textbooks; Biology instruction

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WHAT ARE THE PROS AND CONS OF LIVING HERE?

JAKÉ JSOU VÝHODY A NEVÝHODY BYDLENÍ TADY?

Kateřina Bělohoubková, Eliška Krumlová & Michal Poft

Abstract:

The goals of these project-based lessons are to develop scientific literacy, the development of working with data, its processing and awareness of the possibility of graph manipulation, and to develop communication. The lesson will start with a motivation part, including a presentation on graph manipulation. The class will then be divided into three groups of equal size. Each group will choose a city district in Prague. Then each group will be divided into two equal-sized groups (the group names will be “FOR” and “AGAINST”) by drawing lots. Each group will then have chosen a district and know whether they are arguing for living in that district or against it. The group will have to find general data about the area regarding infrastructure, population and ecology and to have a general overview for the final debate with the rival party. They will need to tabulate the data and create one original and one manipulated graph for the data. There will be a debate between the rival parties at the end of the activity. Parties will be able to argue using their knowledge but also using their own, either original or manipulated graphs. The graphs used by the groups can be manipulated, but at the end of the activity, students must hand in both versions of charts from all three topics. The whole debate will then be judged by the classmates. At the end of the debate, the students will present the valid and manipulated graphs they have made independently to the rest of the class.

Keywords: Statistics; Working with data; Debate; Development of scientific literacy

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STUDENT PERCEPTION OF INCORPORATING IBL ASPECTS INTO BIOLOGY EDUCATION: THE TOPIC OF OWLS

ŽÁKOVSKÉ VNÍMÁNÍ ZAČLENĚNÍ ASPEKTŮ BOV DO VÝUKY PŘÍRODOPISU: TÉMA SOVY

Filip Hašpl, Karel Vojíř & Jan Andreska

Abstract:

Inquiry–based learning (IBL) is one of the ways to acquire scientific skills and thus also scientific literacy. This research focuses on how the students perceive the level of integration of IBL aspects into the teaching of biology in the topic of owls. The aim of this research was to find out how the students perceive lessons with different IBL integration in terms of attractiveness, usefulness and the development of communication skills and intellectual skills, specifically collaboration and information processing. Three lessons on the topic of owls were developed, one at the level of structured IBL, the other guided IBL and the third without IBL elements. 78 lower-secondary school students (7th grade) took part in the research. A questionnaire with 9 Likert scale questions was used after each lesson. Based on a quantitative analysis, it was found that the students are aware of the benefits of IBL in some monitored aspects. These results are alike to similar studies conducted on university and high school students. Awareness of these benefits is important for students' internal motivation.

Keywords: Students' view; Students' attitudes; Inquiry–based science education; Zoology education

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PROJECT-BASED EDUCATION AND STEM - A CASE STUDY

PROJEKTOVÉ VYUČOVANIE A STEM – PRÍPADOVÁ ŠTÚDIA

Gabriel Bánesz, Kristína Komárová & Danka Lukáčová

Abstract:

The contemporary world is rapidly changing, driven by the development of new technologies and a constant influx of new discoveries. These changes require students to acquire new knowledge and skills, which should begin to be cultivated from the early years of secondary education. An appropriate approach for developing these new knowledge and skills is the concept of STEM education. This contribution presents the results of a project undertaken by elementary school students using this educational concept during a technology class. The students were tasked with solving a project whose goal was to assemble a technical system for purifying utility water. In tackling this task, they had to construct a sand filter and a pumping device controlled by a micro:bit. The article discusses the results of the students' projects, and due to the small research sample, qualitative research methods were employed: observation and evaluation of student products. The main aspects evaluated included the correct assembly of the filter, the connection of the pumping device, and the integration of the micro:bit control unit. It was found that students were successful in assembling the filter, but encountered the most significant challenges when it came to connecting the electrical circuits of the pump and the control unit.

Keywords: STEM education; Students' projects; Micro:bit

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MEASUREMENTS OF COGNITIVE LOAD IN SCIENCE EDUCATION

Mária Babinčáková & Paweł Bernard

Abstract:

The learning process is related to the transfer of information from working memory to long-term memory. The effort involved in this process is called cognitive load. The cognitive process is perceived individually and depends, among others, on the specific capacity of working memory. When people receive too much information, the memory cannot process it. That causes memory overload. It is known that the process of learning science subjects requires not only the acquisition of knowledge, but also the use of logical thinking, mathematical skills, practical skills, and spatial literacy. All of this causes cognitive load. Cognitive load can be measured by determining mental effort. Many methods can be used to determine the cognitive load, including subjective methods such as questionnaires, interviews, tests, and objective methods based on measuring the body's physiological reactions, e.g., by eye tracking, heart rate variability or electroencephalography. Monitoring the level of cognitive load allows educators to optimize the teaching/learning process. Within this conference, we will present the above-mentioned theory with a discussion of various types of cognitive load, methods of its measurements and examples of the use of this theory in science education. The results of research on cognitive load and overload are very useful in preparing lesson plans, creating exams, or implementing new technologies into the educational process.

Keywords: Cognitive load; Cognitive overload; Learning; Measurements; Memory; Science

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POPULARIZATION OF BOTANY AT PRIMARY SCHOOLS

POPULARIZACE BOTANIKY NA PRVNÍM STUPNI ZÁKLADNÍCH ŠKOL

Zbyněk Vácha, Jan Petr & Renata Ryplová

Abstract:

The paper focuses on the evaluation of the effectiveness of teaching methods linking botany education with practical life in primary schools. The data were obtained through an experiment where the research sample was divided into two groups - control and experimental. In the control group, the teaching was carried out in a regular classroom using traditional methods (83 pupils), while in the experimental group the teaching was situated in the environment of school gardens and included mainly activation methods of teaching (85). The obtained results point to the fact that teaching with activation elements has a statistically demonstrable effect on the acquisition of new knowledge, but above all on increasing the popularity of botanical topics among primary school pupils.

Keywords: Botany; Primary schools; Experiment

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USE OF VISUAL MODELS IN STEM TASKS TO UNDERSTAND STUDENTS' IDEAS

POUŽITÍ VIZUÁLNÍCH MODELŮ V STEM ÚLOHÁCH K POROZUMĚNÍ MYŠLENEK STUDENT

Lukáš Rokos

Abstract:

Visualisations play a crucial role in STEM education because they offer innovative and effective ways to discover complex concepts, foster the participation of students, and promote deeper learning. They also help to understand students' ideas about various topics. There are various forms of visualisations and visual models in STEM education, e.g., static visualisations, dynamic visualizations and augmented and virtual reality. This presentation is focused on first two forms. The first form is represented by drawings created by students, as well as more sophisticated models related to the specific topic of energy use in professional sport. This example represents a complex activity that was implemented in the curriculum of the specific subject at the university level, and the pilot dissemination was also done at the lower secondary level. The second version is dynamic visualisation in the form of animation connected to the task about Moon and the way in which students used that animation to solve their task. This example is intended to be used as a special hands-on activity at the lower secondary level and was verified with students in the practise. The specific illustrative examples of students' products will be presented as well as analysed following various criteria.

Keywords: STEM; visualization; integrated education; visual models

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EXAMINING EIGHTH-GRADE STUDENTS' UNDERSTANDING OF THE MECHANICAL ADVANTAGES OF GEARS THROUGH SCAFFOLDED ER-BASED STEM INSTRUCTION

Mirac Aydin, Mahmut Tugrul Ilkbahar, Ozlem Ishak & Aysun Ceylan Coskun

Abstract:

Educational Robotics (ER), a form of STEM instruction, encompasses both the acquisition of knowledge and its practical application. Existing literature provides evidence of the effectiveness of ER in fostering comprehension of complex concepts, including speed, energy, torque, animal behaviors, and frictional force. Lego robotics also has the potential to be an effective tool for enhancing learning, as children develop an understanding of the mechanical advantage of gears. However, they still face challenges and concerns when choosing gear combinations to create more powerful and faster cars. We believe this stems from inadequate scaffolding of ER-embedded instruction. To address this issue, we have developed more explicit and flexible ER-enriched instructions to unveil the full potential of ER in science teaching. This study investigates the understanding of mechanical advantage in gears among eighth-grade students using a unique learning environment with Lego robotics. The study employed a one-group pre-and post-test design. Open-ended questions were used to assess students' understanding of the mechanical advantages of gears. The results indicated that more scaffolded ER-enriched science teaching settings enhance students' comprehension of the concept. This is attributed to the provision of scaffolded learning environments, a feature not reported with other tools.

Keywords: Educational robotics; STEM; mechanical advantages of the gears; understanding; eight grade students

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CONTENT ANALYSIS OF WEB OF SCIENCE PUBLICATIONS ABOUT SUSTAINABLE EDUCATION IN SCIENCE CLASSES

OBSAHOVÁ ANALÝZA PUBLIKACÍ O VÝUCE K UDRŽITELNOSTI V PŘÍRODOVĚDNÝCH PŘEDMĚTECH NA WEB OF SCIENCE

Radka Matoušková & Lukáš Rokos

Abstract:

Global warming, deforestation of rainforests, plastic waste, floods, droughts, illegal trade in animals and plants, poaching and many others issues. All these serious phenomena have been in our consciousness for a very long time. Students learn about them at school, we can hear about them on television or radio, or we might read about them in the newspapers. However, another one has come to the fore in recent years that is both very close to them and equally important, sustainability. What has been published about sustainable education? Do we have some examples of good practise? The topic of sustainability, or sustainability education in science education has received a lot of attention and thus many articles have been written. Therefore, in this paper, the results of content analysis of publications available on the Web of Science will be introduced. The key words 'sustainability, sustainable education, science education' were used and the found articles were sorted following the various criteria (e.g., paper type, target group, origin, implications etc.). The results of this analysis will be shown, and the emphasis will be placed on the sources with potential to become good examples for our educational system.

Keywords: Sustainability; science education; content analysis; Web of Science

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CHARACTERISTICS OF EFFECTIVE TEACHER TRAINING PROGRAMS

Rıdvan Elmas, Merve Adıgüzel-Ulutaş & Mehmet Yılmaz

Abstract:

The primary objective of this research is to elucidate the viewpoints teachers hold regarding teacher training programs. In line with the purpose of the research, descriptive research designs, one of the qualitative research designs, was used. The data was collected through a survey comprised of multiple-choice and open-ended questions. The sample consists of 151 science teachers working at Public Schools in Türkiye. The survey was created by the researchers and finalized with expert feedback. The data were analysed through descriptive analysis with percentages. As a result of the research, it was revealed that teachers preferred short periods of training programs, and mostly, they preferred face-to-face or hybrid rather than online sessions. Besides, the teachers preferred training programs related to developing 21st-century skills, laboratory experiments, and real-life problems with an interdisciplinary approach. Most of the teachers stated that they were satisfied with the training programs they received in general for their contribution to their professional development. However, some teachers indicated that many training programs only focused on theoretical knowledge.

Keywords: Teacher Professional Development, Teacher Training Programs, Teacher Training Program Characteristics

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THE CULTURE OF CZECH SCIENCE TEXTBOOKS FROM THE PERSPECTIVE OF ENVIRONMENTAL LITERACY

KULTURA ČESKÝCH UČEBNIC PŘÍRODNÍCH VĚD Z POHLEDU ENVIRONMENTÁLNÍ GRAMOTNOSTI

Karel Vojíř & Silvie Svobodová

Abstract:

In the context of environmental challenges, developing competencies for sustainable development has become a priority in the European Union. Given environmental issues' complexity, scientific knowledge and the social and political context are crucial. Developing environmental literacy is desirable for relevant and evidence-based decision-making and action. The emphasis on its development should then be reflected in the education of all students. For this purpose, it is necessary to provide the appropriate support in the curriculum and educational materials. To understand the current situation in Czechia, research was conducted to find out which aspects of environmental literacy focusing on environmental processes and systems are considered in science textbooks for lower secondary education. To be able to identify and compare subject cultures, an analysis of all textbooks with the Ministry of Education approval clause of all science subjects (N = 127) was conducted. It was found that there are significant differences between science subjects. Most aspects of environmental literacy are included in geography textbooks. In contrast, environmental literacy is marginal in chemistry and especially physics textbooks. The research conducted shows the lack of emphasis on environmental literacy and the uneven development of its aspects in science education and points to issues requiring curriculum innovation.

Keywords: lower secondary education, science education, environmental literacy, textbook analysis

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STRENGTHS AND WEAKNESSES OF USING THE EDUSCRUM METHOD IN PROJECT-BASED SCIENCE EDUCATION

SILNÉ A SLABÉ STRÁNKY VYUŽITÍ METODY EDUSCRUM V PROJEKTOVÉM PŘÍRODOVĚDNÉM VZDĚLÁVÁNÍ

Tomáš Čížek & Karel Vojíř

Abstract:

The learning objectives include developing a range of competencies, further linked within the subject literacies and their application. This is also the case in science education. It is not possible to achieve these educational objectives using traditional transmissive educational methods only. Thus, comprehensive activation methods, including project-based education, are increasingly being discussed. However, these methods meet several challenges and in many cases their complexity proves too demanding, and it is necessary to provide adequate support to students. The EduScurm method offers a solution to developing students' project management skills and tracking outcomes. The aim of this paper is to present the principles of this method as applied to specific cases in the teaching of science in lower secondary education. Considering the importance of students' perceptions for the effectiveness of education, the strengths and weaknesses of this method were investigated. The data collected from the open-ended questionnaire was evaluated using open coding. It was found that students put the most emphasis on developing a collaborative approach to the project for this method. Lack of engagement is the biggest risk from the students' point of view. The method proved to be well applicable in teaching biology and can be used to develop students' competencies.

Keywords: project based education; biology education; lower secondary education

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SHIFT IN PRE-SERVICE TEACHERS' COMPREHENSION OF ECOLOGICAL ROLE OF WATER PLANTS AS IMPACTED BY NEW E-BOOK ON PHOTOSYNTHESIS IN ECOLOGICAL CIRCUMSTANCES

Tereza Brčáková & Renata Ryplová

Abstract:

This contribution brings the results of a pilot study aimed on the impact of the use of new interactive e-book on photosynthesis in pre-service biology teachers' preparation. Shift in pre-service biology teachers' comprehension of the photosynthetic production of water plants was investigated via pre-post-test questionnaire survey. Students' understanding of the aquatic plants role for water ecosystem was assessed by using concept maps. The questionnaire contains several concepts, which are then hierarchically arranged by the students into concept map. The pre-tests discovered low level of comprehension of ecological role of water plants and significant signs of the phenomenon of „plant blindness ". Results of the post tests done after the self-study of a chapter on photosynthesis of water plants in ecological circumstances show improvement of this comprehension. Besides the impact of the new e-book also the possibilities of using concept maps for the assessment of the phenomenon of plant blindness are discussed.

The new e- book on photosynthesis of water plants was developed in frame of the project TL 0500150 supported by TAČR.

Keywords: plant blindness, photosynthesis of water plants, concept map

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CONSTRUCTING BIOLOGICAL TASKS TO DEVELOP SCIENTIFIC SKILLS

KONSTRUKCE BIOLOGICKÝCH ÚLOH PRO ROZVOJ VĚDECKÝCH DOVEDNOSTÍ

Adam Nejedlý & Karel Vojíř

Abstract:

The current social demand for people to be employed in the labour market and to make effective decisions in their everyday lives creates a need for intensive skills development, including skills related to scientific thinking and reasoning. The acquisition of knowledge through scientific processes is an essential part of the development of society. The process aspect of science is constituted by a few specific skills. Exploring students' scientific skills provides insight into the potential for further development of society and advancement in the fields of science, technology, and engineering. In the context of education, there is a need to develop scientific skills through specific tasks. The aim of this contribution is to present the process of developing inquiry-based tasks targeting the development of specific scientific skills. This process has been verified on the construction of two complex tasks for the lower secondary education. Tasks focused on formulating a research question, designing a solution procedure, recording, and processing data, drawing conclusions and interpreting data correctly, and answering the research question. The pilot was implemented in the fall of 2023 in an eighth-grade biology course. The tasks were validated by an expert panel consisting of expert of science didactics and in-service science teachers. Comprehensibility from the students' perspective was observed. The tasks proved to be functional and applicable.

Keywords: Scientific skills; inquiry-based task; lower secondary educations

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THE NEW INTERACTIVE E-BOOK ON PHOTOSYNTHESIS IN ECOLOGICAL CIRCUMSTANCES AND ITS IMPACT ON STUDENTS' KNOWLEDGE OF PHOTOSYNTHETIC BIOMASS PRODUCTION

Renata Ryplová, Štěpánka Chmelová & Zbyněk Vácha

Abstract:

The contribution brings results on a study aimed on the impact of the new digital workbook on photosynthesis in ecological circumstances on the understanding of photosynthetic biomass production and the role of plant biomass in the landscape. The pre/post –test study was carried-out among Czech lower secondary school students. The results of the pre-tests showed lack of students understanding of the term plant biomass itself as well as photosynthetic biomass production and ecological role of plant biomass in landscape. Several traditional misconceptions in understanding of photosynthesis were detected as well. The results of the post-test showed significantly higher improvement of knowledge of students taught by the new interactive workbook compared to the control group taught by traditional teachers' lecture supported by ppt presentation. The students appreciated mainly the animations of the interactive workbook, interactive learning video shots, real world examples and interactive exercises with immediate feedback.

The new interactive workbook on photosynthesis in ecological circumstances was created in frame of the project supported by TAČR TL05000150 and is available online for free at https://fotosyntezavkrajine.cz/.

Keywords: interactive e-workbook; photosynthesis; plant biomass

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UNDERSTANDING ABOUT INSTRUMENTS IN STEAM EDUCATION

Minju Jeong

Abstract:

In STEAM education, knowledge about technology and information are used in a variety of ways. Recently, various digital tools have been introduced to assist in solving problems. As we work on projects, we develop our understanding of the target problem and solution. At the same time, our understanding of tools or instruments grows as well. In this paper, we will focus on the tools or instrument that used to solve problems. We will describe different types of understanding about tools and will look at how they contribute to the problem-solving process and how they develop. Specifically, we will explore how tools such as software, hardware, and abstract knowledge were used in the project to create a mathematical 3D model, and how the understanding expands and grows. Our category of the understanding about tool are 1. usage of a tool, 2. tool suitability, 3. tool mastery and (aesthetic) skill, 4. internal principles of the operation. 5. external federation of tools. Especially, we can consider the aspects of acquisition of mastery and skill can be interpreted as aesthetic understanding of tools.

Keywords: Aesthetic skills; 3D model; tools; Geogebra; Tinkercad; 3D printing

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3D PRINTING AS A VISUALIZATION TOOL IN GEOMETRY COURSES

Angelika Schmid

Abstract:

Modern education has witnessed a shift due to digital technology's transformative impact. GeoGebra is a dynamic mathematics software that enables learners to interactively explore geometric and algebraic concepts, embodying the principles of constructionism. Coupled with 3D printing, it provides an innovative and hands-on approach to teaching geometry. Geometry becomes more engaging and interactive when students can design and model physical representations of geometric objects themselves using GeoGebra software, which they then print out on 3D printers. If visualization is understood as a tool to develop cognitive processes to interpret and understand what is seen, the experience of exploring geometric solids by grasping them in the hands supports and enhances this visual effect. In our contribution, we present several examples of activities that not only deep spatial imagination and develop geometric thinking, but also foster creativity and individuality in our students, future mathematics teachers. The results of our observations confirm 3D printing as a suitable visualization tool to achieve a higher level of spatial understanding.

Keywords: GeoGebra; visualization; 3D printing

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THE FOGGED REALITY: E-CIGARETTES, THE WAY OR HIDDEN EVIL?

ZAMLŽENÁ REALITA: E-CIGARETY, CESTA NEBO SKRYTÉ ZLO ?

Tereza Bryxová, Eva Marešová & Nikola Netušilová

Abstract:

Based on the above-mentioned impressions and discussion, the different parts of the teaching block were designed to make students aware of the harmfulness of e-cigarettes and other tobacco products. During the sub-tasks, students worked independently with information sources, searched for information, examined the contents of e-cigarettes with the help of practical tasks, collected data, sorted the information, and analysed the results of their findings. To collect and analyse the data, the students designed their own questionnaire, which they then shared with a sample of people in a predetermined location. Throughout the program, the change of the students' perceptions towards the issue were observed. The output of the whole session was, among other things, a poster summarizing the issue of electronic cigarettes. An assessment tool was developed to evaluate the teaching session and was presented to the students at the end of the programme. The students were able to use this tool to evaluate the overall programme and the individual tasks, their success and effectiveness.

Keywords: E-cigarettes; project-based learning; nicotine alternatives; impacts on human health

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HOW STUDENTS BALANCE CHEMICAL EQUATIONS IN APPLET: AN EYE-TRACKING STUDY

JAK STUDENTI POSTUPUJÍ PŘI VYČÍSLOVÁNÍ CHEMICKÝCH ROVNIC V APPLETU: EYE-TRACKINGOVÁ STUDIE

Lucie Hamerská & Martin Rusek

Abstract:

Balancing chemical equations is often a challenging and unpopular topic for students. This study focused on freshman students' (N=11) ability to balance chemical equations using an interactive applet. In addition to the chemical equations themselves as a symbolic notation, the applet offered submicroscopic models corresponding to the equation and an atom ratio representation. The students' progress in enumerating the equations in the applet was recorded using eye-tracking and then further explained through a retrospective interview. The results highlight the fact that students balance chemical equations mainly on a symbolic level and are unable to use submicro support. At the same time, the ability of more than half of the students to balance chemical equations was found to not reach the standards required by high school chemistry textbooks. The analysis of the procedures also revealed the most common difficulties that students encounter in balancing chemical equations. The research provides insight into how school practices transfer this topic into chemistry instruction.

Keywords: Applet, balancing chemical equations, chemistry instruction, eye tracking

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GREEN CHEMISTRY - PRACTICAL SOLUTIONS IN THE CHEMISTRY LABORATORY

ZELENÁ CHEMIE - PRAKTICKÁ ŘEŠENÍ V CHEMICKÉ LABORATOŘI

Małgorzata Nodzyńska-Moroń

Abstract:

Laboratory classes are one of the most important elements of chemical education. However, they are often not performed in schools due to the costs of reagents and laboratory glass or for safety reasons. Therefore, it was decided to investigate whether it is possible to replace traditional school experiments with other experimentation techniques. The use of microscale & drop analysis, microwave oven, microscope, on-line laboratories, or simulations was tested. 44 students of master's studies in teaching specialization (biology & chemistry) took part in the research. During the semester, they performed experiments planned for primary school in traditional and modified versions. Then they assessed the modified experiments in terms of safety, environmental nuisance (quality and quantity of waste, electricity and water consumption) as well as in terms of satisfaction with independently performed activities. The obtained results show that students liked the new techniques, but after 8 years of traditional chemistry learning, they did not notice the harmfulness of traditional experiences (consumption of large amounts of reagents, water and electricity, or generation of harmful waste). Therefore, they do not believe it is right to replace traditional experiences more widely with more ecological versions.

Keywords: green chemistry; ecology; laboratory classes

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USING LEARNER'S QUESTIONS ON SUSTAINABILITY AS A TOOL FOR LEARNING

Elif Özdengelen & Jan Lundell

Abstract:

Education for sustainable development is a lifelong learning process. It enhances cognitive, socio emotional, and behavioral dimensions of learning and encompasses learning consent and outcomes, pedagogy, and the learning environment itself. Chemistry education based on ESD principles on all levels must also deals with impacts on ecology, economy, and society. There are some key facts in terms of sustainability education, one of them called different dimensions of engagement: behavioral, cognitive, and emotional engagement. Those dimensions in terms of sustainability as well as to understand sustainability challenges and their complex interlinkages, explore disruptive ideas and alternative solutions. They build core values and attitudes for sustainability, cultivate empathy and compassion for other people and the planet and motivate to lead the change. They also induce practical action for sustainable transformations in the societal, personal, and political spheres. The relevance inbuilt by the sense of real-life effects for individuals becomes relevant whenever learning will affect the student's life. In this work we try to figure out how to integrate sustainability education into chemistry class and use learner-made questions as tool of inquiry and problem-solving. Also, we try to focus on students' questions and try to analyze them to understand their prior knowledge about the topic that can be used as a solid basis for constructive and sustainable chemistry education.

Keywords: sustainability, relevance, engagement, chemistry education

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FROM LAB WORK TO STEAM LEARNING THEME

OD PRÁCE V LABORATOŘI K NÁMĚTU VÝUKY STEAM

Tadeáš Matěcha, Štěpánka Kučková & Karel Štícha

Abstract:

Student activation is an integral part of STEAM education, where science, technology, engineering, art, and mathematics are connected. In this paper, the author presents his own research focused on complex chemical analysis of blood coatings using nano-LC-ESI-Q-TOF tandem mass spectrometry and Fourier transform infrared spectroscopy (FTIR). The partial presentation of the results of the analysis of 41 model samples and two real samples is preceded by the presentation of a didactic transformation of the problem applicable for transfer in the fields of study Teaching for the 2nd stage of primary and secondary schools, namely Chemistry, Biology, Mathematics, Art Education and Information and Communication Technology. The findings from the comprehensive research demonstrate the urgency of linking the fields of study for a more comprehensive insight into the subject matter. This paper presents a proposal for the inclusion of field trips as a means of student activation in STEAM education.

Keywords: STEAM, learning transfer, blood coatings, analytical research

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NURTURING PROBLEM SOLVERS? ASSESSING FINAL-YEAR PRE-SERVICE CHEMISTRY TEACHERS' SKILLS

Martina Tóthová & Martin Rusek

Abstract:

The presented contribution follows the previous one in which freshman pre-service chemistry teachers' problem solving skills were investigated. This study focused on pre-service chemistry teachers in their final year. Their problem-solving skills were, again, measured with the use of two sets of problem tasks–chemistry and general science tasks. The students were given the same tasks as the freshmen and experts in the original study. Each participant completed two computer-based tasks while their eye movements were monitored. Subsequently, retrospective think-aloud sessions and interviews were conducted in order to gather data pertaining to the problem-solving process. The results showed the master students' better, yet unsatisfactory problem solving skills. They also confirmed the original conclusion that students take away the feeling that chemistry problem tasks require only memorization. With respect to their opinion on the nature of the tasks, the students in higher number mentioned they do not see themselves using the tasks as "it requires students to think". The results show the need to enrich the teaching of future chemistry students with scaffolded problem problems and a deeper justification of their role in students' learning.

Keywords: eye-tracking; problem-solving; pre-service teachers; science education

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TEXT DIFFICULTY IN CZECH CHEMISTRY TEXTBOOKS FOR LOWER-SECONDARY SCHOOLS

Martina Sypecká & Martin Rusek

Abstract:

This research explores text difficulty in chemistry textbooks for lower-secondary schools. The study employed eye-tracking technology to observe students as they read, capturing precise reading patterns and linking them with their text understanding. The research sample was chosen based on a pretest utilizing a PISA reading literacy pilot task. Eight students participated in the subsequent measurements, which involved assessing text difficulty using excerpts from two chemistry textbooks with the most readable text published by Fraus and the hardest to read text by the Nová Škola publishers. The students read one text from each textbook. The eye-tracking results were complemented with cued interviews after students finished answering the comprehension questions. The study revealed that proficient readers effectively extracted key information from the text to solve tasks accurately. In contrast, struggling readers encountered challenges with reading comprehension, often resorting to limiting strategies like guessing. Also, new ways of textbook development were confirmed.

Keywords: Chemistry textbooks; text difficulty; eye-tracking

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USING FUNCTION ART TO PROMOTE TRANSDISCIPLINARITY IN STEAM EDUCATION

Guillermo Bautista

Abstract:

The integration of Science, Technology, Engineering, Arts, and Mathematics (STEAM) has gained prominence in educational research, yet it often leans heavily on science and engineering, sidelining mathematics and arts. This paper investigates the transdisciplinary potential of function art, defined as art constructions incorporating mathematical functions, in the context of STEAM education. Grade 11 students in the Philippines used GeoGebra, a freely available mathematics software, to create function art. The study examines the types of functions students use, their strategies, and the implications for STEAM transdisciplinarity. The findings reveal that quadratic, linear, and sine/cosine functions are the most popular, with students using strategies like transformations, reflections, and combining functions with other elements. Function art emerges as a transdisciplinary STEAM approach that bridges mathematics, visual art, and technology, offering a holistic educational experience. This research contributes to addressing the imbalance in STEAM integration and emphasizes the importance of mathematics in a transdisciplinary context.

Keywords: functions art; transformation of functions; transdisciplinarity; steam education

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CONSTRUCTING AND DEBUGGING: LEARNING MATHEMATICS AND COMPUTATIONAL THINKING

Yunianto Wahid & Lavicza Zsolt

Abstract:

Computational thinking (CT) has gained worldwide attention and is argued to be a fundamental skill for the 21st-century era. Some countries have prepared their in-service and pre-service teachers with CT knowledge. Additionally, some countries have made it explicit in the curriculum under computer science subjects or other related subjects such as science and mathematics. To enhance CT skills in mathematics subjects, we design plugged-learning activities where students learn mathematics and CT skills. An educational design research (EDR) has been used to help us develop the activities. We also collaborated with mathematics teachers and an expert to improve the activities. GeoGebra was used to develop the activities, providing students with applets that can be accessed online. There are two main activities, namely constructing and debugging. Students would program geometrical objects using GeoGebra commands. Initially, students would have hints about constructing mathematical objects such as points, polygons, angles, circles, etc. However, the hints presented the different coordinates, vertices, radius, etc, led students to recognize the patterns on the commands. After students are familiar with the commands, they will debug a program. They should find and fix the errors. In the final activity, students will construct mathematical objects without any hints. Most students could accomplish this task.

Keywords: Computational thinking; Mathematics; Construction; Debugging

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BALANCING CHEMICAL EQUATIONS - AND SANDWICHES

VYČÍSLOVÁNÍ CHEMICKÝCH ROVNIC - A SENDVIČE

Malgorzata Nodzyńska-Moroń & Vladimír Sirotek

Abstract:

Therefore, it was decided to investigate whether this application is equally useful in teaching older students who have already learned chemistry and balancing of chemical reactions. But for whom it still causes problems. A total of 287 students were examined. The students were divided into groups according to how many years they have been learning chemistry. Research results show that the longer students learn chemistry, the more difficult it is for them to understand this analogy. As an explanation for this fact, psychological concepts such as negative transfer, pro- and retro-active inhibition and stimulus generalization can be mentioned.

Keywords: Balancing chemical equations, Learning by analogy, Pro- and retroactive inhibition

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STEAM LEARNING ACTIVITIES FOR TRANSFORMING EXPERIENCES OF MARGINALIZED STUDENTS IN INTEGRATED MATHEMATICS, LANGUAGE, ARTS AND TECHNOLOGY CLASSROOM

Musa Saimon

Abstract:

STEAM education approach is well accepted as one of the best approaches to enhance learners' knowledge and skills development for meeting the demands of the 21st Century era. One of the targets for Sustainable Development Goal (SDG) 4 is to improve the learning experience of diverse learners especially in the subjects for basic foundational literacy skills such as mathematics, language, arts and technology. However, marginalized students face various challenges such as those related to access to learning resources, knowledge gaps, interaction with peers and lack of proficiency in language instructions. Therefore, the present study proposes STEAM learning activities for transforming the classroom experiences of marginalized students in integrated Mathematics, Language, Arts, and Technology (MLAT). The study employed a design-based research approach. The activities proposed in this study are a result of the design phase and are thus conceptually developed. The findings show that STEAM learning activities that can transform the learning experiences of marginalized learners are sharing what they are used to doing in their home places through various media such as posters, songs, etc. Developing a manual guide for those who want to participate in activities of their experience. Reflect on the skills and knowledge needed to accomplish the tasks that they engage in in their home places. Furthermore, we discuss and provide implications of the proposed activities. In the further phases of the study, we expect to test and evaluate the proposed activities.

Keywords: Education for Sustainable Development; Marginalized Students; STEAM education approach

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USING CHATGPT-3.5 IN CHEMISTRY EDUCATION

VYUŽITÍ CHATGPT-3,5 VE VÝUCE CHEMIE

Milada Teplá, Kateřina Trčková, Roman Maršálek, Martin Žáček, Veronika Švandová, Leoš Sáblík & Pavel Teplý

Abstract:

The article focuses on the utilization of artificial intelligence, specifically ChatGPT-3.5, as a potential tool for use in chemistry education. When using artificial applications, including ChatGPT-3.5, teachers and students may encounter certain risks. ChatGPT has been trained with data up to September 2021 and cannot provide the latest insights. Furthermore, some data may be misinterpreted, leading to misconceptions. Other risks include plagiarism, the generation of non-existent citations, incorrect (chemical) calculations, incorrect chemical equation balancing, and inaccurate Czech nomenclature. However, there are still numerous ways to effectively and efficiently employ ChatGPT-3.5 in education. One of them is lesson preparation. The model can assist teachers in designing content, including methodological approaches with the inclusion of activation methods. It can also generate questions suitable for tests, for instance. ChatGPT-3.5 can also be used to create stories, fairy tales, and even theater plays with a chemical theme. It can be equally effective in designing laboratory activities or even aiding in the creation of escape games. Overall, despite the aforementioned risks associated with using ChatGPT-3.5 in chemistry education, there are many ways to harness this technology for enhancing teaching and motivating students to engage actively in learning.

Keywords: Artificial Intelligence, ChatGPT-3,5, Chemistry Education

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THE TRIAD OF TERROR SHOWDOWN: TEACHER ARGUMENTS UNLEASHED

Michal Blaško, Martin Rusek & Svatava Janoušková

Abstract:

In response to ongoing curriculum reforms aimed at reducing content and innovating teaching approaches, our study, ""The Triad of Terror Showdown: Teacher Arguments Unleashed,"" utilized the Delphi method to gather insights from active chemistry teachers. This research aimed to understand the factors influencing the inclusion of chemistry nomenclature, calculations, and formula balancing in the curriculum and the extent to which these elements should be preserved. Key findings included: Emphasis on an individualized approach to teaching nomenclature, recognizing the unique learning needs of each student. The importance of students comprehending the principles and practical applications of chemistry, not just memorizing names and formulas. Varied opinions on the depth and breadth of instruction for inorganic nomenclature. Advocacy for flexible teaching methods, such as interactive games and competitions, to engage students effectively. Recognition of the historical and linguistic significance of preserving chemistry nomenclature as a unique cultural reference. Concerns about overusing nomenclature in testing, stressing the need to balance evaluation and effective learning. Varied opinions on the ideal duration and teaching methods, highlighting the necessity of flexibility. Emphasis on the interconnectedness of nomenclature with other chemistry-related themes. In conclusion, this study offers valuable insights into the discourse on retaining nomenclature, chemistry calculations, and formula balancing in the curriculum. It underscores the need for adaptable approaches that cater to the diverse needs and perspectives of both students and educators in the evolving educational landscape.

Keywords: Chemistry curriculum revision; Subject-matter choice; Triad of terror

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