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**PROJECT-BASED EDUCATION AND OTHER STUDENT-ACTIVATING
STRATEGIES AND ISSUES IN STE(A)M EDUCATION**

XXII.

BOOK OF ABSTRACTS

Dominika Koperová & Martin Rusek (Eds.)

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doc. PhDr. Martin Rusek, Ph.D.

Mgr. Dominika Koperová, PhD.

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Mgr. Tadeáš Matěcha

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FUNDAMENTAL DRIVERS OF INQUIRY IN THE LABORATORY

Hendra Y. Agustian

Abstract

Laboratory work is a cornerstone of science education, providing students with hands-on experiences that bridge theory and practice. Recent research highlights how laboratory settings foster engagement through epistemic affect (emotional involvement in learning) and epistemic conation (motivation and volition). Epistemic affect involves curiosity, joy, and frustration or doubt, with positive emotions encouraging exploration, while managed challenges promote deeper inquiry. Amusement often emerges as a key positive emotion, underscoring the value of supportive emotional climates. Epistemic conation includes grit, goal orientation, and self-regulation; perseverance helps students overcome setbacks, while collaborative planning and goal setting enhance lab success.

These factors also contribute to students' professional identity as scientists, as practical lab experiences foster a sense of self. Collaborative labs promote a shared purpose, further reinforcing the relevance of scientific practices. A holistic approach to lab education integrating cognitive, emotional, and motivational elements prepares students for scientific inquiry and suggests broader applications in STEM education. Project-based and active learning can similarly benefit by addressing these affective and motivational dimensions, fostering not only knowledgeable but also resilient scientists.

Contact address:

Dr. Hendra Y. Agustian

Department of Science Education, University of Copenhagen,
Niels Bohr Bygningen, Universitetsparken 5, 2200 Copenhagen, Denmark

e-mail: hendra.agustian@ind.ku.dk

SMART DEVICES IN PHYSICS EDUCATION: OPPORTUNITIES AND CHALLENGES

Petr Káčovský

Abstract

Post-covid abundance of communication and sharing platforms, the „bring your own device“ trend, or the explosive growth of artificial intelligence place increasing demands on the digital competences of both students and teachers. In physics teaching and learning, one more important aspect stands out: smart devices allow us to explore physics processes and phenomena that would otherwise remain hidden, beyond the reach of our senses and common teaching aids. But to what extent does this make education more effective and, vaguely said, “better”? What is known about the effects of using smart devices on students’ learning gain or their interest in physics/science?

This talk aims to provide a mosaic of different perspectives on the use of smart devices (primarily smartphones) in physics or generally science lessons. We will start with theoretical frameworks for digital competences, such as DigComp or DiKoLan, and continue with examples of some devices and apps that have become popular in teachers’ and educators’ community. Demonstrations of specific teaching ideas will be supplemented by references to current research results, focusing on learning gain and student interest/motivation.

Contact address:

RNDr. Peter Káčovský, Ph.D.

Charles University in Prague, Faculty of Mathematics and Physics, Department of Physics Education,
V Holešovičkách 2, 182 00 Praha 8V Holešovičkách 2, 182 00 Praha 8

e-mail: petr.kacovsky@matfyz.cuni.cz

EASIER KNOWING THAN DOING: PROJECT-BASED LEARNING ON ENVIRONMENT PROTECTION FOR ELEMENTARY STUDENTS

Kuohung Huang

Abstract

This study was conducted at an elementary school in rural Taiwan. Cricket education is the school-based curriculum because the school breeds a massive amount of crickets for educational purposes. Students of this school have opportunities for hands-on experiences and knowledge of crickets. Most students perform well on the cognition test about crickets. Nevertheless, many students, particularly girls, do not like or care about crickets and their habitat. An inquiry-learning project was launched to raise students' awareness and concerns about crickets and the surrounding environment. Using GIS software, six students participated in a three-month project investigating the quantity and distribution of crickets in the school area. The results show that students improve in science attitude, GIS skills, and inquiry learning, although they feel pressured by these untraditional learning activities. More importantly, students develop concerns about the local environment after interacting with teachers, peers, and insects for a longer time.

Contact address:

prof. Dr. Kuohung Huang

National Chiayi University, Department of E-learning Design and Management,
85 Wen-long Village, Ming-Hsiung, Chiayi 621, Taiwan

e-mail: kuohung@mail.ncyu.edu.tw

BIOLOGY INSTRUCTION IN CASE STUDIES: LESSONS LEARNED AND FUTURE PROSPECTS

Martin Jáč

Abstract

Biology instruction at secondary schools should focus on developing students' comprehensive understanding of basic principles of life along with the acquisition of scientific inquiry skills. Even though biology education research addresses a wide range of research topics, we still do not have enough evidence about the variables that influence the quality of biology instruction, which can thus metaphorically resemble a black box. This paper will summarize a decade of qualitative research on school biology teaching and learning using a content-focused approach. Based on educational case studies elaborated with the use of the 3A methodology and further in-depth analysis using the multiple-case study approach we will describe particular aspects of teaching biology in schools including (a) reasoning across ontologically different levels as a central challenge in biology teaching and learning; (b) students' acquisition of biological misconceptions as a result of misdirected teaching of core concepts; (c) constructive cognition during biology inquiries. Representative examples from biology lessons will be highlighted using transcripts of teaching and learning situations and conceptual structure diagrams. The comprehensive research model linking a content-focused research of biology instruction with the 3A methodology, and the Model of Educational Reconstruction will be presented to outline new avenues for future research on the quality of biology instruction at secondary schools.

Contact address:

RNDr. Martin Jáč, Ph.D.

Palacký University Olomouc, Faculty of Education, Department of Biology
Purkrabská 2, 779 00 Olomouc, Czech Republic

e-mail: martin.jac@upol.cz

EXAMINING CHATGPT'S VALIDITY AS A SOURCE FOR SCIENTIFIC INQUIRY AND ITS MISCONCEPTIONS REGARDING CELL ENERGY METABOLISM

Rıdvan Elmas, Merve Adiguzel Ulutas & Mehmet Yilmaz

Abstract

Technological innovations and the increasing adoption of Artificial Intelligence (AI) technologies have created a need to assess their impact on education. ChatGPT (Conversational Generative Pre-Trained Transformer), an AI chatbot developed by OpenAI in 2022, possesses notable educational capabilities. This research aims to evaluate the accuracy of ChatGPT's responses to scientific questions related to biochemistry. Five three-tier biochemistry questions were posed to ChatGPT, and its responses were analyzed for scientific accuracy. The study revealed that ChatGPT produced incomplete or incorrect answers to all five questions. Additionally, when prompted to verify the accuracy of its answers, the chatbot persistently maintained its incorrect responses. While it delivered somewhat accurate responses to the first two questions, it provided only partially correct answers to the third and consistently incorrect answers to the remaining questions. Consequently, ChatGPT's ability to generate scientifically accurate responses was found to be limited. Educators must recognize that the quality of their questions dramatically influences the accuracy of ChatGPT's responses. Therefore, well-crafted questions are essential for obtaining more precise and comprehensive answers. Teachers should also be aware that ChatGPT may present misconceptions and should only be used as a scientific resource under careful academic review.

Keywords: Artificial intelligence; AI; Misconceptions; Biochemistry; ChatGPT

Contact address:

Assoc. Prof. Dr. Rıdvan Elmas

Afyon Kocatepe University Faculty of Education Department of Science Education,
Ahmet Necdet Sezer Kampüsü Eğitim Fakültesi, 03200 AFYONKARAHİSAR
e-mail: relmas@aku.edu.tr

Dr. Merve Adiguzel Ulutas, Prof. Dr. Mehmet Yilmaz

Gazi University Faculty of Gazi Education, Department of Science Education, Emniyet, Gazi
Üniversitesi Rektörlüğü, Bandırma Cad. No:6/1, 06560 Yenimahalle/Ankara
e-mail: merveadiguzel@gazi.edu.tr, myilmaz@gazi.edu.tr

VISUAL AND COGNITIVE ASPECTS OF CHEMISTRY EXPERIMENTS: INVESTIGATING THE BENEFITS OF VIDEO AND REAL DEMONSTRATIONS

Tereza Bryxová & Martin Rusek

Abstract

The paper focuses on the results of piloting a tool to monitor differences between video and live demonstrations in terms of their effectiveness in achieving cognitive and affective educational goals. Third-year undergraduate chemistry education students observed pairs of demonstrations (proofs of common gases, highly exothermic reactions, and demonstrations of chlorine and acetylene properties), with one demonstration presented via video and the other performed live. After viewing each demonstration, each student completed a worksheet containing questions focused on describing the observed reaction, items assessing the affective component of the lesson (adapted from *Advancing Chemistry by Enhanced Learning in the Laboratory Project*), and a question focused on the detailed description and interpretation of the chemical nature of the observed reaction, which was completed as a group. An audio recording was made of the group activity (focus group discussions). Analysis of students' records and discussions suggests that students primarily perceive the effect of the demonstrations, while the chemical nature of the reactions often escapes them. The findings further highlight the benefit of live demonstrations, particularly due to the presence of the demonstrator, though without further impact on their understanding of the demonstrated reaction and mention the need for support in the form of symbolic representations (formulas and equations). In contrast, video demonstrations are rated as more illustrative. The results thus indicate the need for further investigation into the effect of so-called signalling and the potential use of augmented reality (adding sub-micro representations) in video demonstrations.

Keywords: Video demonstration; Eye-tracking; Chemistry education

Contact address:

Mgr. Tereza Bryxová, doc. PhDr. Martin Rusek, Ph.D.

Charles University, Faculty of Education, Department of Chemistry and Chemistry Education
M. Rettigové 4, 116 39 Praha 1 – Nové Město
email: tereza.bryxova@pedf.cuni.cz, martin.rusek@pedf.cuni.cz

IT IS TIME TO BUILD SKYSCRAPERS!

Yosep Dwi Kristanto & Zsolt Lavicza

Abstract

This study proposes a digital task sequence aimed at creating an intellectual need for students to use graphs. At the start of this task sequence, students play the role of skyscraper builders. They are tasked with selecting the location of two buildings on opposite sides of a street and explaining their choice of location. Next, they are presented with a problem: how does the distance between the skyscrapers relate to people driving on the street? To solve this problem, students are asked to create a presentation consisting of images and text, intended to encourage the use of varied strategies. These varied student strategies serve as an entry point to introduce graphs as an efficient tool for solving the problem. A lesson case is used to demonstrate the implementation of this digital task sequence.

Keywords: Graphs; Digital task design; Intellectual needs

Contact address:

Yosep Dwi Kristanto, M.Pd., Univ.-Prof.Zsolt Lavicza

Johannes Kepler University Linz Linz School of Education, Department for STEM Didactics
Altenberger Straße 68, 4040 Linz, Austria
email: yosepdwikristanto@usd.ac.id, zsolt.lavicza@jku.at

ENVIRONMENTAL ANXIETY AND SELF-EFFICACY IN THE AGE OF AI

Josef Šedlbauer, Jan Činčera & Martina Štrojsová

Abstract

Students' environmental anxiety is a strong underlying emotion that must be considered in any environmental education program. Ideally, this type of education should lead to the fostering of constructive hope, or self-efficacy, in the participants. We tested this assumption on a group of 88 undergraduate students participating in the Environmental Science course at the Technical University of Liberec. As part of the course, students articulated their environmental concerns and were then assigned a seminar paper focused on possible solutions to one of the issues from their list. As a side project, we tested the possible influence of AI tools on the results. About half of the students were asked to primarily use an AI tool of their choice to prepare their seminar papers. Environmental anxiety and self-efficacy were measured before and after the course. The results showed a significant increase in both components, while the influence of AI was not discernible. The implications of these findings will be discussed in the presentation.

Keywords: Environmental anxiety; Self-efficacy; AI

Contact address:

prof. Ing. Josef Šedlbauer, Ph.D.

Technical University of Liberec, Faculty of Arts, Sciences and Education, Department of Chemistry
Studentská 1402/2, 461 17 Liberec 1

e-mail: josef.sedlbauer@tul.cz

doc. PhDr. Jan Činčera, Ph.D.

Masaryk University in Brno, Faculty of Social Sciences, Department of Environmental Studies
Joštova 218/10, 602 00 Brno

e-mail: 96852@mail.muni.cz

RNDr. Martina, Štrojsová, Ph.D.

Technical University of Liberec, Faculty of Arts, Sciences and Education, Department of Biology and Ecology, Studentská 1402/2, 461 17 Liberec 1

e-mail: martina.strojsova@tul.cz

CANDLE BURNING UNDER THE MICROSCOPE: HOW LABORATORY TRIALS DEVELOP STUDENTS' SCIENCE SKILLS

HOŘENÍ SVÍČKY POD LUPOU: JAK LABORATORNÍ POKUSY ROZVÍJÍ PŘÍRODOVĚDNÉ DOVEDNOSTI STUDENTŮ

Lucie Vydrová, Lucie Podveská & Filip Novák

Abstract

This learning activity focused on students' science process skills' development, more precisely their ability to perform measurements and follow a given procedure. A topic previously explored at the authors' team department focused on a phenomenon of candle burning students are familiar with and was inspired by a previously piloted activity using gas sensors. In the activity, students examined changes in oxygen and carbon dioxide levels during reactions and their effects on candle combustion. It was designed for lower-secondary school students and first-year vocational school students. They measured candle burning time in a closed container under three conditions: in air, in an oxygen-enriched environment, and in carbon dioxide using gas probes. Their results showed students' occasionally simplified answers due to false understanding, however demonstrated solid knowledge of combustion. After the experiment, their grasp of laboratory measurement procedure and safety-consciousness improved, leading to better application of knowledge and its increased accuracy.

Keywords: Measurements; Oxygen and carbon dioxide levels; elementary school; gas sensor

Contact address:

Bc. Lucie Vydrová, Bc. Filip Novák, Bc. Lucie Podveská

Charles University, Faculty of Education, Department of Chemistry,

Magdalény Rettigové 4, 116 39 Praha 1, Česká republika

email: lucie.vydrova.99@gmail.com, filanovy@gmail.com, podveskaluci@gmail.com

A DETECTIVE GAME AS A TOOL TO FIND OUT WHO POISONED THE WATER IN PRAGUE

DETEKTIVNÍ HRA JAKO NASTROJ POZNANÍ ANEB KDO OTRÁVIL VODU V PRAZE

Jakub Sohar, Karolína Mašková, Bára Kožíšková & Klára Kotmelová

Abstract

This study presents a gamified chemistry activity promoting environmental responsibility and critical thinking, aligned with the revised Framework Educational Program (FEP). Designed for upper primary and lower secondary students, the activity focuses on water pollution, a core FEP topic. The interactive game, *Who Poisoned the Water in Prague?*, uses escape-room principles to engage students as detectives investigating water contamination. Over two lessons, students work in teams, analyzing water samples to identify the fictional C.A.C. Industries as the pollution source. The game's structure fosters data analysis, communication, and problem-solving skills, while supporting environmental awareness and 21st-century competencies. Through hands-on tasks, students filter and examine water, enhancing their understanding of real-world issues. An initial survey assessed students' prior knowledge of environmental responsibility, followed by a post-game reflection involving self-assessment and peer feedback. Results showed increased engagement and improved comprehension of water pollution's complexity, suggesting that gamification is a valuable tool for science education, enhancing awareness of sustainability topics.

Keywords: Investigation; Water pollution; Environmental awareness

Contact address:

Bc. Jakub Sohar, Bc. Karolína Mašková, Bc. Bára Kožíšková, Bc. Klára Kotmelová

Charles University, Faculty of Education, Department of Chemistry,

Magdalény Rettigové 4, 116 39 Praha 1, Česká republika

email: jakub.sohar@gmail.com, karolina.maskova@icloud.com, bara.koziskova@seznam.cz,

klara.kotmelova@volny.cz

EKOPOLIS – GAMIFICATION OF THE SUSTAINABLE DEVELOPMENT GOALS

EKOPOLIS – GAMIFIKACE CÍLŮ UDRŽITELNOSTI OSN

Martina Sypecká & Laura Kdýrová

Abstract

This study examines the integration of gamification in chemistry education through a project addressing the United Nations' Sustainable Development Goals (SDGs). Conducted with 9th-grade students at a lower-secondary school, the study implemented a board game to promote active engagement with sustainability concepts. The game's interdisciplinary design encouraged students to explore environmental, economic, and social dimensions of sustainability through interactive simulations that mirrored real-world challenges and opportunities. Within a structured classroom setting, participants made strategic decisions to invest in sustainable initiatives while responding to global challenges affecting their progress. This approach fostered critical thinking, collaboration, and broadened students' understanding, aligning with competencies emphasized in the national education framework. To measure impact, students completed a pre-test, participated in the game, and engaged in a reflective session involving self-assessment and evaluation of teamwork. Results showed that while over 65% of students initially lacked knowledge of sustainability, post-game reflections revealed increased awareness, with over half demonstrating the ability to analyze diverse sustainability areas and their interconnections. These findings highlight gamification's potential in enhancing sustainability education and suggest its applicability across diverse learning environments.

Keywords: Sustainable development goals; Environmental education; Gamification

Contact address:

Bc. Martina Sypecká, Bc. Laura Kdýrová

Charles University, Faculty of Education, Department of Chemistry,
Magdalény Rettigové 4, 116 39 Praha 1, Česká republika
email: sypeckam@gmail.com, kdyrova.laura@gmail.com

ARTIFICIAL INTELLIGENCE IN THE PREPARATION OF CHEMISTRY STUDENT TEACHERS AND TEACHERS

UMĚLÁ INTELIGENCE V PŘÍPRAVĚ STUDENTŮ UČITELSTVÍ A UČITELŮ CHEMIE

Veronika Švandová, Leoš Sáblík & Kateřina Klebanová

Abstract

This contribution presents experiences with the implementation of artificial intelligence (AI) in teaching future chemistry teachers at the Faculty of Science of Masaryk University in the spring of 2024, as well as in courses preparing practical chemistry teachers in the autumn of 2024. The pilot integration of tools using AI (text and graphic generators) will be briefly presented) focusing on the following text generators: ChatGPT, Copilot, Deeply (now Editee), and graphics generators: Copilot Designer, Deeply, Midjourney, ChatGPT-4, Canva and class preparation generation applications (e.g., ScioBot). In addition to showing how teaching students and teachers can work with the mentioned applications, the educational use of individual tools will be presented, and the positives and negatives arising from the work of this target group with artificial intelligence will be summarized. Furthermore, a questionnaire survey of the participants of the mentioned educational activities will be presented, examining their experiences with individual applications, ways of using artificial intelligence, or their attitudes towards using artificial intelligence in connection with teaching before and after the completed course.

Keywords: AI; Chemistry; Teacher

Contact address:

Mgr. Veronika Švandová, Ph.D., Mgr. Leoš Sáblík, Mgr. Kateřina Klebanová

Masaryk University, Faculty of Science, Department of Didactics of Chemistry, Department of Chemistry, Kamenice 753/5, 625 00 Brno, Czech Republic
email: 106381@mail.muni.cz, sablik@mail.muni.cz, 247965@mail.muni.cz

TEACHER PROFESSIONAL DEVELOPMENT IN ACTIVATING STRATEGIES IN EDUCATION ABOUT NATURE AND PLACE

Kateřina Čiháková

Abstract

This contribution is focused on teachers' own perspectives on the benefits of different forms of professional development particularly in inquiry-based education (IBSE) and outdoor education, their views on the implementation of these approaches and the benefits to pupils. It brings results of qualitative research using focus group, semi-structured interviews and lesson observation from participants in various programmes and results from quantitative analysis of questionnaires from participants of online course and teachers downloading online teaching materials. Results show that teachers with more training in IBSE, can more accurately characterize the method and are more likely to engage students in formulating research questions and investigation designs than those who only know it from 1 course or reading. A correlation was found between the frequency of outdoor teaching and the frequency of IBSE for all samples evaluated. The teachers perceive longer programmes as beneficial, if they can try out the methods themselves as participants and in their own teaching and improve their planning. They emphasise the role of a community of teachers (both real and virtual) with shared teachers' beliefs, as well as the initiation of such a group in the school. Their motivation for professional development in outdoor learning and IBSE are their values (especially the relationship with nature), they do not purposely pursue a shift in pupils' knowledge and skills. They are active in changing the context, in particular adapting the outdoor environment for learning, but rather not updating school curricular documents. In general, primary school teachers (ISCED 1) appear to be more active in introducing outdoor learning and IBSE into their own teaching and in influencing colleagues at school. Thus, professional development programmes should be prepared based on the values and professional beliefs of the participants, purposefully creating a community and bringing together active teachers from ISCED 1 and ISCED 2 with an interest in outdoor learning and IBSE.

Keywords: Teacher professional development; Mentoring; Inquiry-based science education; Outdoor education

Contact address:

Mgr. Kateřina Čiháková

Katedra biologie, Pedagogická fakulta, Jihočeská univerzita v Českých Budějovicích
Jeronýmova 10, 371 15 České Budějovice
e-mail: katerina.cihakova@muzeum.ricany.cz

RELATIONSHIP BETWEEN KNOWLEDGE OF THE COOLING EFFECT OF PLANTS AND STUDENTS' ATTITUDES TOWARDS PLANTS – PRELIMINARY FINDINGS

Tereza Brčáková & Renata Ryplová

Abstract

This study explores the relationship between knowledge of the cooling effect of plants and attitudes of 8th and 9th-grade students towards plants, a topic related to the phenomenon known as "plant blindness." This concept describes people's inability to perceive plants as significant components of our environment. The study was conducted in the South Bohemia region with a control and experimental group of students (N = 211), with data collected in June 2024. Results showed a weak positive correlation between knowledge of plants and their cooling effect and students' attitudes, influenced by the type of educational program. In the group using project-based learning with modern technologies, there was a statistically significant improvement in both knowledge and positive attitudes, while traditional teaching brought only limited changes. These findings suggest that innovative educational approaches can more effectively promote awareness of the importance of plants in the context of climate change. The study provides new insights into how educational programs can influence students' attitudes towards plants and their knowledge of plants' ecological functions.

Keywords: Attitudes; Knowledge; Plant Awareness

Contact address:

Mgr. Tereza Brčáková, RNDr. Renata Ryplová, Ph.D.

University of South Bohemia in České Budějovice, Faculty of Education, Department of Biology
Jeronýmova 10, 371 15, České Budějovice, Česká republika
email: brcakt00@jcu.cz, ryplova@pf.jcu.cz

IDENTIFYING AND EVALUATING TOOLS FOR CHEMISTRY LAB EDUCATION: A COMPREHENSIVE REVIEW

Dominika Koperová, Allen A. Espinosa, Tadeáš Matěcha & Martin Rusek

Abstract

The effectiveness and benefits of laboratory education continue to be widely debated, with many researchers pointing out the disconnect between the intended and implemented curriculum in relation to practical activities. This paper forms part of the STExperiMents project (Preparation and Evaluation of Experiments for Effective Undergraduate Teacher Training in STEM Disciplines) and presents preliminary findings aimed at identifying tools for evaluating laboratory experiences and assessing the effectiveness of practical activities in chemistry. A comprehensive review of research literature was conducted to identify validated assessment tools for practical activities. An in-depth analysis of 51 papers revealed a varied range of available tools but highlighted significant limitations, such as the scarcity of instruments suitable for assessing laboratory experiences, the absence of a universally applicable assessment tool, and the lack of a standardised validation process for these tools. This paper provides an overview of current tools and exposes the gaps that need to be addressed to effectively evaluate the impact of experimental activities across all levels of education.

Keywords: Laboratory education; Assessment tools; Chemistry education

Contact address:

Mgr. Dominika Koperová, PhD., Dr. Allen A. Espinosa, Mgr. Tadeáš Matěcha,
doc. PhDr. Martin Rusek, Ph.D.

Charles University, Faculty of Education, Department of Chemistry,
Magdalény Rettigové 4, 116 39 Praha 1, Česká republika
email: dominika.koperova@pedf.cuni.cz, allen.espinosa@pedf.cuni.cz,
tadeas.matecha@pedf.cuni.cz, martin.rusek@pedf.cuni.cz

EMPOWERING FUTURE SCIENCE TEACHERS: INTEGRATING INTERSECTIONALITY, IDENTITY, AND POSITIONALITY IN THE TEACHER EDUCATION CURRICULUM

Allen A. Espinosa & Martin Rusek

Abstract

Understanding one's intersectionality, identity, and positionality is fundamental to establishing equity and social justice in classrooms, making it essential for teacher education programs to support pre-service teachers in forming their professional identities. This study examines how science teacher education programs integrate these principles, assessing their impact on teacher preparedness, identifying associated challenges, and exploring strategies for effective implementation. Through key informant interviews and online surveys with pre-service teachers, science teacher educators, and department heads at a teacher education institution in Prague, Czech Republic, the inductive thematic analysis shows that these concepts, while implicitly discussed in courses like didactics, psychology, and pedagogy, are rarely integrated explicitly. Key themes that emerged include mentorship initiatives for critical reflection, challenges related to conceptual clarity, and limited curriculum specificity, especially within science-focused disciplines. Although indirect assessment methods, such as role-playing and situational exercises, promote reflective learning, structured guidance on these topics remains underdeveloped. Findings suggest that clearer definitions and formalized assessment standards, alongside enhanced curriculum inclusion, could better equip pre-service teachers to address the social dimensions of science education.

Keywords: Intersectionality; Positionality; Identity; Science teacher education; Equity and social justice

Contact address:

Dr. Allen A. Espinosa, doc. PhDr. Martin Rusek, Ph.D.

Charles University, Faculty of Education, Department of Chemistry,
Magdalény Rettigové 4, 116 39 Praha 1, Česká republika
email: allen.espinosa@pedf.cuni.cz, martin.rusek@pedf.cuni.cz

SCHOOL PRINCIPALS' PERSPECTIVES ON THE ROLE OF ARTIFICIAL INTELLIGENCE IN EDUCATION

Rıdvan Elmas & Merve Adiguzel Ulutas

Abstract

This study aims to examine school principals' general attitudes towards AI. A survey model, one of the quantitative research methods, was used in the study. The sample consists of 82 school principals working in an international private school chain. General Attitudes toward Artificial Intelligence scale developed by Schepman & Rodway (2020) was used as a data collection tool in the study. Permission for the use of the scale has been obtained. The scale comprises 20 items and follows a 5-point Likert format, ranging from "strongly disagree" to "strongly agree." The scale includes twelve positively and eight negatively worded items. The collected data were analyzed descriptively. A frequency table was created for school administrators' responses to the items. As a result, the school principal endorsed some positive items with high frequency. However, principals were more reluctant to endorse items comparing humans with AI. School administrators reported that they mostly agreed with some of the negative aspects of artificial intelligence. However, while they mostly disagreed with the item stating that artificial intelligence is dangerous, they agreed with the item stating that artificial intelligence violates human privacy. The results indicate that school administrators hold both positive and negative perceptions of artificial intelligence, depending on the context.

Keywords: Artificial Intelligence; AI; Attitudes; School Principals

Contact address:

Assoc. Prof. Dr Rıdvan Elmas

Afyon Kocatepe University, Faculty of Education, Department of Science Education
Ahmet Necdet Sezer Kampüsü Eğitim Fakültesi / 03200 AFYONKARAHİSAR
email: relmas@aku.edu.tr

Dr. Merve Adiguzel Ulutas

Gazi University, Faculty of Gazi Education, Department of Science Education
Bandırma Caddesi Abant sk No:5 Hersek / 320C Yenimahalle / ANKARA
email: merveadiguzel@gazi.edu.tr

HOW CHEMISTRY TEACHERS IN SECONDARY SCHOOLS IN A SELECTED REGION OF THE CZECH REPUBLIC REFLECT THEIR OWN ACTIVATION STRATEGIES IN TEACHING THE TOPIC OF NATURAL SUBSTANCES

JAK REFLEKTUJÍ VLASTNÍ AKTIVIZAČNÍ STRATEGIE VE VÝUCE TÉMATU PŘÍRODNÍ LÁTKY UČITELÉ CHEMIE NA ZÁKLADNÍCH ŠKOLÁCH VE VYBRANÉM REGIONU ČESKÉ REPUBLIKY

Monika Pelikánová, Martin Bílek & Milan Šmíd

Abstract

The paper focuses on the reflection on the actual use of activation strategies in the context of teaching the topic Natural substances (especially Carbohydrates, Fats, Proteins and Vitamins) in 9th grade secondary schools in the Ústí nad Labem region. On the basis of semi-structured interviews with chemistry teachers we analyse their current approaches to teaching this thematic unit with an emphasis on innovative teaching methods and organisational forms, including their subjectively perceived effectiveness. We present specific examples of activation strategies that teachers say they have been able to implement successfully and discuss their potential for improving both learning outcomes and increasing students' interest in chemistry and its teaching. The paper offers insight into the practice of Czech teachers on a selected topic with interdisciplinary potential and provides inspiration for further development of activation approaches in science teaching.

Keywords: Activation strategies; Teaching chemistry; Natural substances; Teacher self-reflection

Contact address:

Mgr. Monika Pelikánová, prof. PhDr. Martin Bílek, Ph.D.

Charles University, Faculty of Education Department of Chemistry and Didactics of Chemistry,
Magdalény Rettigové 4, 116 39 Praha 1
email: moncapelikanova@seznam.cz, martin.bilek@pedf.cuni.cz

RNDr. Milan Šmíd, Ph.D.

University of Jan Evangelista Purkyně, Faculty of Science, Department of Chemistry
Pasteurova 3632/15, 400 96 Ústí nad Labem
email: m.smidl@seznam.cz

EVALUATION OF THE INTERACTIVE ELECTRONIC TEXTBOOK BIOMASS IN SUSTAINABLE LANDSCAPES IN SECONDARY SCHOOLS

EVALUACE INTERAKTIVNÍ ELEKTRONICKÉ UČEBNICE BIOMASA V TRVALE UDRŽITELNÉ KRAJINĚ V PROSTŘEDÍ STŘEDNÍCH ŠKOL

Zbyněk Vácha & Renata Ryplová

Abstract

This paper describes the results of evaluating the e-textbook Biomass in Sustainable Landscapes in a Secondary School. From a cognitive perspective was evaluated the impact of the textbook on the development of knowledge of photosynthetic biomass production, energy flows and ecological contexts. The evaluation also focused on validating the affective goals of education. The investigation was realised in four secondary schools, and 185 first-year students participated. Data collection was based on a controlled pre-test - post-test system. The results indicate that the electronic textbook is a suitable supplement in teaching photosynthetic issues to achieve cognitive but mainly affective learning objectives.

Keywords: Biomass; Photosynthesis; Electronic textbook; Secondary school

Contact address:

PhDr. Zbyněk Vácha, Ph.D., RNDr. Renata Ryplová, Ph.D.

University of South Bohemia in České Budějovice, Faculty of Education, Department of Biology,
Jeronýmova 10, 371 15 České Budějovice
email: zvacha@pf.jcu.cz, ryplova@pf.jcu.cz

ORIENTATION IN THE BIOTECHNOLOGY JUNGLE: UNRAVELING STUDENTS' MISCONCEPTIONS

ORIENTÁCIA V BIOTECHNOLOGICKEJ DŽUNGLI: ODHAĽOVANIE MYLNÝCH PREDSTÁV ŠTUDENTOV

Michaela Horniaková

Abstract

The research focuses on identifying students' main preconceptions and misconceptions in the field of modern biotechnology. The research focuses on 9th grade lower secondary school students (n = 20). Semi-structured interviews with individual respondents were used as the main research instrument. The interviews contain 28 questions divided into four areas: biotechnology, genetic engineering, genetically modified organisms and cloning. The data collected was analysed using grounded theory, inductive coding and a modified Certainty of Response Index (CRI) method. The results show that students have a relatively low conceptual understanding of biotechnology as a whole. In particular, when students have a basic knowledge of biotechnology, they have difficulty relating it to other categories such as genetic engineering and/or GMOs. The results also highlight common misconceptions, such as associating biotechnology with machines and misunderstanding genetic engineering as genealogy. In addition, students showed a significant lack of understanding of genetic engineering as a whole but were aware of its positive impact on society. Teachers should help students understand the relevance of the content and engage with it effectively, as modern biotechnology is often controversial and raises many questions.

Keywords: Modern biotechnology; Misconceptions; Students; 9th graders

Contact address:

Mgr. Michaela Horniaková

Palacký University in Olomouc, Faculty of Education, Department of Biology,
Žižkovo nám. 5, 77900, Olomouc
email: michaela.horniakova@upol.cz

USING THE RESEARCH METHOD ON THE EXAMPLE OF THE XANTHOPROTEIN REACTION

VYUŽITÍ BADATELSKÉ METODY NA PŘÍKLADU XANTOPROTEINOVÉ REAKCE

Barbora Hanušová, Rafael Doležal, Martin Bílek & Karel Kolář

Abstract

The teaching experiment has an indispensable role in teaching. The object of investigation of this thesis is to study the interaction of nitric acid with proteins. The course of the reaction is motivating and inspiring for pupils and students due to the observable changes that occur. The course of the reaction involves asking several questions. In order to answer them, the student must explain the nature of the reactions. A bioorganic model based on simple reactions carried out on a dot-plate is sufficient to explain the reaction process. The main motivation for this activity was to enrich the existing range of simple teaching experiments in organic chemistry and biochemistry with an experiment using exploratory methods in the context of bioorganic models.

Keywords: Nitric acid; Proteins; Xanthoprotein reaction; School experiment

Contact address:

Bc. Barbora Hanušová, doc. Mgr. et Mgr. Rafael Doležal, Ph.D., prof. PhDr. Martin Bílek, Ph.D.,
prof. Ing. Karel Kolář, CSc.

Charles University, Faculty of Education, Department of Chemistry,
Magdalény Rettigové 4, 116 39 Praha 1, Česká republika
email: hanusbarbora@seznam.cz, rafael.dolezal@pedf.cuni.cz, martin.bilek@pedf.cuni.cz,
karel.kolar@pedf.cuni.cz

PROJECT BASED EDUCATION AS AN EDUCATIONAL METHOD IN THE PREPARATION OF SCIENCE TEACHERS IN THE CZECH REPUBLIC

PROJEKTOVÉ VYUČOVÁNÍ JAKO VZDĚLÁVACÍ METODA V PŘÍPRAVĚ UČITELŮ PŘÍRODOVĚDNÝCH PŘEDMĚTŮ V ČR

Irena Plucková, Kristýna Havelková & Jan Válek

Abstract

Project-based education is a teaching approach that seeks the comprehensive development not only of primary and secondary school students, but also of future science teachers. Through linking different learning areas into meaningful thematic units, student teachers learn and experience new learning strategies that extend not only their teaching competencies. The method enables a more effective link between theory and practice, supports the development of key competences of teachers and students, as well as critical thinking, collaboration and creativity. Teacher students are more motivated with this method as it connects practice with the teaching environment, reflecting their experiences and interests. The article presents concrete examples of successful application of project-based and then integrated thematic teaching focused on the theme "Life as in a greenhouse" in the Czech educational environment, including an analysis of pedagogical approaches in the implementation of these teaching strategies. Furthermore, the challenges that teachers face in integrating science thematic teaching are discussed, as well as ways to overcome barriers to implementation in the educational process at different school levels. The aim of the article is to foster a deeper understanding of project-based and integrated thematic education as modern educational strategies that not only improve the learning process but also develop students' competencies needed for life in an ever-changing world.

Keywords: Project-based education; Integrated thematic teaching; Teacher competencies; Critical thinking; Educational strategies

Contact address:

Mgr. Irena Plucková, Ph.D.¹, Mgr. Kristýna Havelková^{1,2}, PhDr. Jan Válek, Ph.D.¹

¹Masaryk University, Faculty of Education, Department of Physics, Chemistry and Vocational Education, Poříčí 7, 603 00 Brno, Czech Republic
email: pluckova@ped.muni.cz, havelkova@ped.muni.cz, valek@ped.muni.cz

²Charles University, Faculty of Science, Department of Chemistry Education, Hlavova 2030/8, 128 00 Praha 2 - Nové Město, Czech Republic

BEYOND TEXT: THE ROLE OF NON-TEXTUAL COMPONENTS IN CHEMISTRY LEARNING MATERIALS

Lucie Hamerská & Martin Rusek

Abstract

This study explores the impact of non-textual components in chemistry learning materials on students' ability to engage with them. Special attention was given to students' work with the most frequent and field-specific components: graphs, tables, and chemical representations at submicroscopic and symbolic levels. The paper reports on a pilot study designed to evaluate students' engagement with learning materials containing the specific components. Multi-tier tasks were developed and reviewed by an expert panel, then tested on a larger sample of students ($N = 20$), and on a smaller sample ($N = 6$) using eye-tracking. The tasks required students to select answers, justify their choices, and rate their confidence. The content scores, total scores, and confidence judgement were analysed to assess the students' performance. Eye-tracking was specifically employed to study how students interpret graphical representations. This approach was supplemented with think-aloud protocols and interviews to gather data on students' visual behaviour and thought processes during task solving. Following the pilot study, the materials were refined to better distinguish between different levels of student interaction with each component and will be used in the future research. The findings highlight specific areas that impede learning, providing insights into students' needs. These insights are critical for refining educational practices in science subjects and enhancing teacher training programs.

Keywords: Eye-tracking; Chemistry education materials; Non-textual components

Contact address:

Mgr. Lucie Hamerská, doc. PhDr. Martin Rusek, Ph.D.

Charles University, Faculty of Education, Department of Chemistry,
Magdalény Rettigové 4, 116 39 Praha 1, Česká republika
email: lucie.hamerska@pedf.cuni.cz, martin.rusek@pedf.cuni.cz

DRAWING SURFACES ON REALITY: AR APP FOR LEARNING GEOMETRY

Alessandro Martinelli

Abstract

The importance of direct interaction with teaching material, as outlined by Dewey in the late 1900s, highlights numerous gaps that are still present in higher education today compared to the potential offered by modern immersive technologies toward constructivist participation in the contents learned. The aim of this research is therefore to demonstrate the effectiveness of an Augmented Reality (AR) teaching application, called GeoTry, dedicated to cataloging and visualizing 3D geometries to support secondary education. The Project-Based Learning (PBL) approach is implemented in this case by adding a challenge to what would be the normal AR visualization: the students themselves must draw the geometries they will study. In fact, within the app, a feature has been developed with which the user can draw their own personalized geometries in space, with a fluid stroke of the finger recorded in real time, even tracing real objects. From this function, once the "drawing" is completed, surfaces are generated on which the software automatically prepares a set of properties to explain. The case study is ruled surfaces, which students, alone or in groups, learn to build gradually through direct experience and design, comparing them with a catalogue of examples. The app has been tested in higher education environments on numerous classes with evidence of a positive impact both on engagement and on the speed and quality of learning.

Keywords: AR; Geometry; Visualization; App; STEM Education

Contact address:

Dr. Alessandro Martinelli, Univ.-Prof. Zsolt Lavicza

Johannes Kepler University, Linz School of Education, STEM Education

Altenbergerstrasse 68, 4040, Linz, Austria

email: martinelli.arc@gmail.com, zsolt.lavicza@jku.at

PRACTICAL, GREEN AND SUSTAINABLE CHEMISTRY IN CZECH SCHOOLS: A DREAM OR REALITY?

Martin Rusek

Abstract

In recent years, practical experimentation in school chemistry has garnered renewed focus, challenging assumptions that chemistry's experimental nature naturally engages students in hands-on learning. In 2023, IUPAC initiated a global survey—the International Teacher Survey on Green and Sustainable Chemistry (GSC) Practical Activities—targeting chemistry teachers worldwide to map the integration of green and sustainable practices in classrooms. This initiative, conducted across more than 50 countries. In Czechia, the survey saw participation from over 1,060 teachers from lower and upper-secondary schools, providing an in-depth look into the state of chemistry experimentation. The results revealed that while the importance of green chemistry and sustainability is recognized, practical applications in Czech schools are often limited, with many teachers citing challenges such as inadequate resources, lack of training, and curriculum constraints. Findings indicate that most students primarily engage in theory-driven activities, limiting the development of essential scientific skills and conceptual understanding fostered through hands-on experimentation. These insights highlight the pressing need to enhance teacher training, focusing on integrating sustainable chemistry practices into the curriculum. Addressing these gaps could improve not only student engagement but also their understanding of chemistry's role in addressing real-world environmental challenges.

Keywords: Green Chemistry; Sustainable Chemistry Education; Practical Activities in Chemistry; IUPAC Teacher Survey

Contact address:

doc. PhDr. Martin Rusek, Ph.D.

Charles University, Faculty of Education, Department of Chemistry,
Magdalény Rettigové 4, 116 39 Praha 1, Česká republika
email: martin.rusek@pedf.cuni.cz

DESIGN THE ORTHOGRAPHIC PROJECTION ON ENGINEERING DRAWING MODULE BASED ON PROJECT-BASED WITH 3D PRINTING AND MODELING MECHANICAL OBJECT

Andri Setiyawan, Zsolt Lavicza, Yosep Dwi Kristanto & Alessandro Martinelli

Abstract

This research aims to design an Orthographic Projection module for engineering drawing based on project-based learning with 3D printing and mechanical object modeling, specifically tailored for vocational high schools within the Merdeka Curriculum framework. The study focuses on developing lesson plans that incorporate 3D modeling software and 3D printing technology to enhance students' technical drawing skills and hands-on experience in translating 3D mechanical objects into accurate orthographic projections. The module was designed with project-based learning principles, encouraging active student participation in real-world applications of engineering drawing concepts. To ensure its relevance and effectiveness, the module was subjected to expert validation by experienced vocational education teachers and lecturers in engineering education. Feedback was gathered on the appropriateness of the content, pedagogical approaches, and alignment with the Merdeka Curriculum. The results of the expert validation indicate that the module is pedagogically sound, engaging, and applicable in vocational high school settings, providing a modernized approach to teaching engineering drawing in line with contemporary industrial needs.

Keywords: Module; Vocational education; Orthographic projection; Project-based

Contact address:

Andri Setiyawan, S.Pd., M.Pd., Univ.-Prof. Zsolt Lavicza, Dr. Alessandro Martinelli,
Yosep Dwi Kristanto

Johannes Kepler University, Linz School of Education, STEM Education

Altenbergerstrasse 68, 4040, Linz, Austria

email: andryaam@gmail.com, zsolt.lavicza@jku.at, alessandro.martinelli@jku.at,

yosepdwikristanto@usd.ac.id

LEARNING CHEMISTRY ONLINE BY KITCHEN CHEMISTRY

Asmo Roponen, Jouni Väliisaari & Jan Lundell

Abstract

Online learning is meant to provide unique form of learning with its own strengths and challenges. Some strengths of online learning are enhanced by flexibility in time and place, by accessibility to a wider audience and by immediate feedback. Inquiry-based-learning is an overarching theme in science education. It focuses on giving students their own experiences with a chance of active learning and reflective thinking, instead of presenting observed phenomena by mere facts and theories. Inquiry-based experiments are known to improve student engagement, which enhances learning, critical thinking and understanding of scientific methods. Cooking-related contexts typically interest a larger audience since all people have personal relationship with food. Moreover, the context of kitchen chemistry can increase interest and enthusiasm in studying chemistry, and engage in learning new things about common contexts. At the University of Jyväskylä, a kitchen chemistry online chemistry course was created as a part of the open university's continuous learning program to educate about chemistry. The goal was to build learning modules that would teach chemistry in relevant and meaningful contexts, and to make connections between chemistry and everyday phenomena. The main content of the course, besides describing the theory of the chemistry of food preparation, were food-themed assignments to enable the learners to conduct scientific experiments in their own homes.

Keywords: Online education; Kitchen chemistry; Relevance; Experimenting

Contact address:

Asmo Roponen, Dr. Jouni Väliisaari, Prof. Jan Lundell

University of Jyväskylä, Faculty of Mathematics and Science, Department of Chemistry

P.O.Box 35, 40014 University of Jyväskylä

email: asmo.t.roponen@jyu.fi, jouni.k.valisaari@jyu.fi, jan.c.lundell@jyu.fi

CHEMICAL EXPERIMENTS IN PRESCHOOL: OBSERVATION CHILDREN'S MANUAL SKILLS AND THEIR INTEREST IN STEM

CHEMICKÉ POKUSY V MATEŘSKÉ ŠKOLE: POZOROVÁNÍ MANUÁLNÍCH DOVEDNOSTÍ DĚTÍ A JEJICH ZÁJEM O STEM

Jana Prášilová & Kamila Petrželová

Abstract

This preliminary study focuses on conducting chemical experiments in a kindergarten environment with a focus on observing children's manual skills and self-evaluation of their work. During several chemical experiments, the children tried basic chemical operations, such as mixing, measuring liquids and weighing solids. We observed their ability to work both with a measuring cylinder and a beaker, measure with a spoon and weigh on a scale. In addition, we encouraged self-reflection by asking children to evaluate their own work. Through discussion and a questionnaire, we discovered a lively interest in children in understanding how different substances are produced and the processes behind everyday phenomena. This approach not only strengthened their scientific literacy, but also nurtured a sense of curiosity and excitement about the world of science, laying the foundation for future learning in STEM fields.

Keywords: Preschool; STEM; Chemical experiments; Manual skills

Contact address:

Mgr. Jana Prášilová, Ph.D., Mgr. Kamila Petrželová, Ph.D.

Palacký University Olomouc, Faculty of Science, Department of Inorganic Chemistry
17. listopadu 12, Olomouc, 77900, ČR
email: jana.prasilova@upol.cz, kamila.petrzelova@upol.cz

CONSTRUCTION OF OBSERVATIONAL TASKS AIMED AT DETERMINING SPECIFIC FEATURES OF AN ORGANISM

KONSTRUKCE POZOROVACÍCH ÚLOH ZAMĚŘENÝCH NA URČENÍ SPECIFICKÝCH ZNAKŮ ORGANISMU

Filip Hašpl & Karel Vojíř

Abstract

The development of scientific observation, as one of the key skills of scientific literacy, is essential not only for the successful use of scientific knowledge in the school environment, but also in everyday life and professional contexts. In biology, this skill plays an important role, e.g. for species identification, yet there is a lack of tasks specifically targeting this skill. To address this, the aim was to develop a methodology for designing tasks aimed at observing morphological features on organisms and to develop a set of tasks. The tasks are designed to be simple, free of specialized terminology, easy to administer and evaluate, and not time-intensive on the students. Criteria were also set for the selection of photographs of organisms to make them suitable for the development of observation, reducing the influence of knowledge of specific organisms and simulating real-world biological observations by depicting entire organisms in a way that mirrors how biologists observe them in the field. A set of 36 tasks was created. These tasks cover a wide range of groups, including vertebrates and invertebrates for animals, angiosperms and gymnosperms for plants, and unicellular and multicellular organisms for microcosms. The focus is on key morphological features such as shape, colour, and pattern. The tasks have been content-validated and are designed to be used both for skill development and for testing the level of development of the skill to observe biological markers.

Keywords: Scientific skills; Scientific observation; Task development; Lower secondary school education

Contact address:

Mgr. Filip Hašpl, PhDr. Karel Vojíř, Ph.D.

Charles University, Faculty of Education, Department of Biology and Environmental Studies
Magdalény Rettigové 4, 116 39 Praha 1, Czech Republic
email: filip.haspl@pedf.cuni.cz, karel.vojir@pedf.cuni.cz

THERE IS NO VIDEO EXPERIMENT LIKE A VIDEO EXPERIMENT

NENÍ VIDEOPOKUS JAKO VIDEOPOKUS

Radana Koudelíková

Abstract

Understanding and memorizing chemical equations, as a part of inorganic chemistry education, remains a significant challenge for most high school students as well as for beginners in chemistry-related fields at universities. With the growing interest in interactive and visual learning methods, not only from students but also from educators, multimedia tools are becoming essential for the effective transmission of knowledge in scientific disciplines. The creation of appropriate materials that serve as valuable aids and study resources requires considerable attention to the development of multimedia tools. An analysis of specific challenges faced by students studying inorganic chemistry reveals areas where existing study materials fail to address learning difficulties. Proper filming and editing of video experiments can have a profound impact not only on understanding complex concepts but also on motivating students. A crucial factor remains how a well-produced video should be constructed and the specific impact such multimedia resources can have. Preliminary results of our investigation suggest that even well-made videos, from an educator's perspective, do not achieve the desired effect in conveying knowledge to students. The most important future steps, therefore, involve creating high-quality video materials from the student's perspective to enhance the teaching of inorganic chemistry and improve the overall educational process.

Keywords: Chemical equations; Education; Interactive learning; Multimedia

Contact address:

Mgr. Radana Koudelíková

Palacký University Olomouc, Faculty of Science, Inorganic chemistry

17. listopadu 1192, 779 00 Olomouc, Czech Republic

email: radana.koudelikova01@upol.cz

FORMATION OF METAL DENDRITES DURING ELECTROLYSIS: AN INQUIRY-BASED PROJECT FOR SECONDARY SCHOOLS

TVORBA DENDRITŮ KOVŮ PŘI ELEKTROLÝZE: BADATELSKÝ PROJEKT PRO STŘEDNÍ ŠKOLY

Milan Šmídl & Zuzana Maňásková

Abstract

This work deals with the formation of metal dendrites during the electrolysis of aqueous metal salt solutions as a form of inquiry-based activity in secondary education. The main aim was to investigate the formation of dendritic metal structures, commonly demonstrated in education (e.g., silver, copper, lead, and tin), and to extend this investigation to other metals, such as zinc, cadmium, iron, aluminum, and others. The study focused on the dependency of dendrite formation on various factors, including the type of metal compound, applied voltage, electrode material, solution concentration, and solvent used. Research questions and hypotheses were formulated and verified through experimental methods. The results of the experiments showed that metals like iron, cadmium, cobalt, and zinc are capable of forming dendrites under given conditions. In contrast, metals such as lithium, magnesium, titanium, chromium, and manganese did not form dendritic structures. These findings can serve as a valuable basis for expanding inquiry-based education not only in secondary schools but also in primary education. This study offers a new perspective on the possibilities of experimental teaching in chemistry and may serve as an inspiration for further inquiry-based projects focusing on electrolysis and metallurgy.

Keywords: Metal dendrites; Electrolysis; Inquiry-based learning; Secondary school; Experimental chemistry

Contact address:

RNDr. Milan Šmídl, Ph.D., MBA.

Jan Evangelista Purkyně University in Ústí nad Labem, Faculty of Science, Department of Chemistry,
Pasteurova 3544/1, 400 96 Ústí nad Labem, Czech Republic
email: smidl@humanitas.cz

Zuzana Maňásková

Charles University, Faculty of Science, Section of Geology,
Albertov 6, 128 00 Praha 2, Czech Republic
email: zuzana.manaskova@natur.cuni.cz

THE ADMISSIONS PROCESS AND ITS ROLE IN ADMISSIONS PROCESS AT THE FACULTY OF SCIENCE, CHARLES UNIVERSITY

PŘIJÍMACÍ ŘÍZENÍ A JEHO ROLE V AKADEMICKÉ ÚSPĚŠNOSTI NA PŘF UK

Milada Teplá

Abstract

Academic success is currently one of the key indicators of the quality of higher education. At the Faculty of Science, Charles University, written entrance exams play a crucial role in selecting students for undergraduate programs. This paper/presentation focuses on the significance and predictive value of these tests. It also examines the correlation between the results of written entrance exams and subsequent academic success, including students' grades, completion rates, and overall performance. The research highlights the importance of well-designed entrance exams as a tool for predicting long-term academic success and emphasizes the need for their continuous improvement to meet the evolving skill requirements in the scientific field.

Keywords: Admissions process; Admissions process; Chemistry; Education

Contact address:

doc. RNDr. Milada Teplá, Ph.D.

Charles University, Faculty of Science, Department of Chemistry Education
Albertov 6, 128 43, Prague, Czechia
email: milada.tepla@natur.cuni.cz

WHAT DOES WATER HIDE?

CO UKRÝVÁ VODA?

Jan Hrdlička, Alena Šrámová & Lenka Sedláková

Abstract

Supplementing traditional "indoor" education with outdoor education can help increase student's motivation and create space for all-round student education. The purpose of outdoor education is to connect the subject matter as much as possible with the real environment and what pupils can actually observe around them. (Venkovní výuka, n.d.) The outdoor thematic education "What water hides" was one of the choices for the inter-subject thematic days for the second year of secondary school. In the field of chemistry, the teaching focused on the measurement of selected properties of water in the natural environment. The springs in the village of Svatý Jan pod Skalou were selected for the measurements. This place is easily available from Beroun and the local springs are in a karst area, where have a higher content of some ions. The content of these ions is relatively easy to determine and there is also a slightly higher pH than usual, which can be easily determined with a pH meter. Students completed simple pre- and post-measurement tests as a part of the topic day. As part of their participation in the topic day, they made a short presentation. This presentation was intended to convey the knowledge and experience gained to the other students in the year-class. These presentations were given in a moderated 'conference'.

Keywords: Outdoor education; STEM; Chemistry education

Contact address:

Ing. Jan Hrdlička, Ph.D., Mgr. Alena Šrámová

University of West Bohemia, Faculty of Education, Department of Chemistry

Veleslavínova 42, Plzeň, 306 14

email: hrdlicka@kch.zcu.cz, sramova.alca@gmail.com

Mgr. Lenka Sedláková

University of West Bohemia, Faculty of Education, Centre for Biology, Geosciences and the Environment, Chodské náměstí 1, Plzeň, 306 14

email: sedlakova@gymberoun.cz

THE ROLE OF SECONDARY EDUCATION IN SHAPING CONCEPTUAL UNDERSTANDING AND COGNITIVE BIASES IN CHEMISTRY EDUCATION IN CZECHIA

Marta Kuhnová, Dominika Koperová, Allen A. Espinosa & Martin Rusek

Abstract

In this study, we assessed first-year chemistry students' confidence in their conceptual understanding of chemical concepts related to water in Czechia. Specific items from the original Chemistry Concept Inventory (CCI) were selected and contextualized around the topic of water. These six items were adapted into a three-tier format to evaluate students' comprehension of phase transitions, molecular behavior, and intermolecular forces. This three-tier diagnostic tool enabled us to measure both content knowledge and confidence judgments. The test was administered in a General Chemistry course at the beginning of the Winter 2022 semester to identify students' initial understanding, underlying misconceptions, and potential gaps. Findings indicate that students tend to rely more on rote memorization rather than achieving a deeper understanding of chemical concepts.

Keywords: Three-tier test; Chemistry concept inventory, Conceptual understanding

Contact address:

Mgr. Marta Kuhnová, PhD., Mgr. Dominika Koperová, PhD., Dr. Allen A. Espinosa,
doc. PhDr. Martin Rusek, Ph.D.

Charles University, Faculty of Education, Department of Chemistry,
Magdalény Rettigové 4, 116 39 Praha 1, Česká republika
email: marta.kuhnova@pedf.cuni.cz, dominika.koperova@pedf.cuni.cz, allen.espinosa@pedf.cuni.cz,
martin.rusek@pedf.cuni.cz

BIRDWATCHING IN THE NON-BREEDING SEASON: A LONG-TERM PROJECT FOR YEARS 7-9 IN SECONDARY SCHOOL

POZOROVÁNÍ PTÁKŮ V MIMOHNÍZDNÍM OBDOBÍ: DLOUHODOBÝ ŠKOLNÍ PROJEKT PRO 2. STUPEŇ ZŠ

Miia Aine Tissari & Dagmar Říhová

Abstract

This study deals with creating and implementing a long-term school project focused on birdwatching and bird species identification in the non-breeding season. Over a seven-year period, ten 7th-9th grade classes (in total 181 pupils) from two elementary schools participated in the project. At the beginning and end of the project, pupils were tested on identifying 33 local bird species that commonly visit or are seen around bird feeders. Birdwatching occurred from mid October to mid-March at bird feeders the pupils had placed near their homes. The pupils regularly recorded their observations in their bird journals. This project fell under the science curriculum but was also integrated as a cross-curricular project into other subjects, especially art education. The project improved the pupils' knowledge and skills, increased their interest in birds, and raised their awareness of the need for bird conservation. Pupils became significantly more proficient in using the resources and equipment needed to observe and identify birds. The pupils' interest in nature, especially in their immediate surroundings, increased markedly. The results show that long-term natural science-based projects can positively impact education, help build environmental awareness, and form and strengthen pupils' feelings of stewardship toward nature.

Keywords: Ornithology; Environmental education; Project-based learning

Contact address:

Mgr. et Mgr. Miia Aine Tissari, Mgr. Dagmar Říhová, Ph.D.

Charles University, Faculty of Education, Department of Biology and Environmental Studies,
Magdalény Rettigové 4, 116 39 Praha 1, Czech Republic
email: cayetania@seznam.cz, dagmar.rihova@pedf.cuni.cz

KNOWLEDGE OF PLANT ECOSYSTEM SERVICES AMONG SOUTH BOHEMIAN PUPILS

Renata Ryplová

Abstract

Plant ecosystem services are topic of STEM education. The importance of plants can be appreciated based on their ecosystem services, i.e. the benefits that humans obtain from ecosystems. Despite plants providing all four types of ecosystem services (provisioning, regulating, supporting, and cultural) human tends to underestimate and ignore plants in their environment (phenomenon of plant blindness). In education. This contribution brings results of a study aimed on the knowledge of plant ecosystem services done among 122 basic school ninegraders in the region of South Bohemia. The results show, that except for cultural services, respondents possess very limited knowledge of plant ecosystem services. Photosynthetic oxygen production and human food production are integral components of supporting ecosystem services, and students learn about these topics in their lessons on photosynthesis. Notably, while most students acknowledged these two aspects of photosynthesis, carbon storage or CO₂ reduction by plants is mostly underestimated. Similarly, the knowledge of regulatory services related to the plant's role in the mitigation of climate change consequences was very low. These results indicate the necessity to include plant ecosystem services and STEM into climate education to foster an understanding of plant role in the mitigation of consequences of climate changes

Keywords: STEM; Plant ecosystem services; Climate education; Plant Blindness

Contact address:

RNDr. Renata Ryplová, Ph.D.

University fo South Bohemia, Faculty of Education, Department of Biology
Jeronýmova 11, 371 15 České Budějovice, CZ
email: ryplova@pf.jcu.cz

CHEMICAL CALCULATIONS IN TEACHER TRAINING: IDENTIFIED STRATEGIES AND COMMON ERRORS

*Dominika Koperová, Veronika Machková, Iveta Bártová, Vladimír Sirotek,
Jitka Štrofová, Petr Šmejkal, & Martin Rusek*

Abstract

Chemical calculations are considered as one of the critical areas in both lower and upper secondary school chemistry curricula, however, research suggest, that university students often struggle with fundamental types of calculations. This study examines the ability of first-year university chemistry students to solve basic chemical calculation problems. A total of 547 students from six universities in the Czech Republic completed a test covering essential calculations, including mass fraction, molar concentration, stoichiometric calculations, dilution of solutions, and pH. Qualitative analysis of responses ($n = 235$) identifies the most frequently used methods leading to correct answers, as well as common errors leading to incorrect results. Results indicate that 36.8% of students employed the strategies leading to correct results, 34.2% did not attempt the calculations, and 29% made predominantly conceptual errors (25.5%) in their calculations. These findings reflect the level of high school chemistry curriculum mastery among students who selected chemistry as their field of study, with strategies often corresponding to those in secondary school textbooks.

Keywords: Chemistry calculations; Chemistry teacher students; Student Strategies

Contact address:

Mgr. Dominika Koperová, PhD., doc. PhDr. Martin Rusek, Ph.D.
Charles University, Faculty of Education, Department of Chemistry,
Magdalény Rettigové 4, 116 39 Praha 1, Česká republika
email: dominika.koperova@pedf.cuni.cz, martin.rusek@pedf.cuni.cz

RNDr. Veronika Machková, PhD.
University of Hradec Králové, Faculty of Science, Department of Chemistry,
Hradecká 1285, 500 04, Hradec Králové 3

Mgr. Iveta Bártová, Ph.D.
Palacký University in Olomouc, Faculty of Science, Department of Inorganic Chemistry,
17. listopadu 12, 77900, Olomouc

PaedDr. Vladimír Sirotek, CSc., Mgr. Jitka Štrofová, Ph.D.
University of West Bohemia, Faculty of Education, Department of Chemistry
Veleslavínova 42, Plzeň, 306 14

RNDr. Petr Šmejkal, Ph.D.
Charles University, Faculty of Science, Department of Chemistry Education
Hlavova 2030/8, Prague 2, Czech Republic

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