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ZÁŽITKOVÉ VZDELÁVANIE V CHÉMII - PODPORA ZÁUJMU A ENVIRONMENTÁLNEHO POVEDOMIA U ŽIAKOV ZÁKLADNÝCH ŠKÔL

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EXPERIENTIAL EDUCATION IN CHEMISTRY - ENHANCING INTEREST AND ENVIRONMENTAL AWARENESS IN PRIMARY SCHOOL PUPILS

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ABSTRAKT
Tento článok sa zaoberá implementáciou zážitkového vzdelávania v predmete chémia, ktorého sa zúčastnili žiaci zo základnej školy Kornela Mahra v Trnave. Cieľom bolo poskytnúť žiakom praktické a interaktívne skúsenosti, ktoré by podporili ich záujem o chémiu a chemické procesy prebiehajúce v životnom prostredí. Žiaci mali možnosť sami si realizovať jednoduché pokusy v chemickom laboratóriu pod vedením vysokoškolských pedagógov. Vedľajším cieľom zážitkového vzdelávania bolo zvýšiť environmentálne povedomie u žiakov, a to prostredníctvom prepojenia medzi uskutočnenými chemickými experimentmi, ich aplikáciami v prírode a vysvetlenia ich významu pre životné prostredie.

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Na základe rozhovorov so žiakmi realizovaných bezprostredne po ukončení zážitkového vzdelávania ako aj z rozhovorov uskutočnených s odstupom času, možno konštatovať, že zážitkové vzdelávanie zvyšuje motiváciu a záujem žiakov o chémiu, ako aj ich schopnosť aplikovať nadobudnuté vedomosti v nasledujúcich vyučovacích hodinách.Na druhej strane, zo štruktúrovaného rozhovoru s pani učiteľkou vyplýva, že väčšina žiakov zatiaľ nedokázala pochopiť prepojenie medzi chemickými experimentmi a procesmi prebiehajúcimi v prírode, čo oslabilo potenciálny vplyv na ich environmentálne povedomie. Článok prináša cenné poznatky a odporúčania pre pedagógov a odborníkov vo vzdelávaní o integrácii zážitkovej formy výučby a praktických pokusov pri budovaní pochopenia základných princípov chémie a tiež súvislostí s ochranou životného prostredia u mladších žiakov.

Kľúčové slová:*chémia, základná škola, zážitkové vzdelávanie, životné prostredie*

ABSTRACT
This article deals with the implementation of experiential education in the subject of chemistry, which was attended by pupils from the Kornel Mahr secondary school in Trnava. The goal was to provide pupils with practical and interactive experiences that would support their interest in chemistry and chemical processes taking place in the environment. Pupils had the opportunity to carry out simple experiments themselves in the chemical laboratory under the guidance of university teachers. A secondary goal of the experiential education was to increase pupils' environmental awareness, through the connection between the conducted chemical experiments, their applications in nature and the explanation of their importance for the environment.
On the basis of interviews with pupils carried out immediately after the end of experiential education, as well as from interviews carried out after a while, it can be concluded that experiential education increases pupils' motivation and interest in chemistry, as well as their ability to apply the acquired knowledge in the following lessons. On the other hand, the structured interview with the teacher shows that the majority of students have not yet been able to understand the connection between chemical experiments and processes taking place in nature, which has weakened the potential impact on their environmental awareness. The article provides valuable knowledge and recommendations for educators and experts in education about the integration of experiential teaching and practical experiments in building an understanding of the basic principles of chemistry and the connections with environmental protection among younger students.

Key words: *chemistry, primary schools, experiential learning, environment*

INTRODUCTION

For primary and secondary school pupils, chemistry often seems like a complex and abstract subject, difficult not only to understand but also to learn. By engaging in hands-on experiences and practical activities, we can show children how chemistry influences their everyday lives and the environment they live in. This approach fosters their curiosity and encourage them to explore the world around them in a way that is both funny and vital for their future.

Experiential learning is an innovative and currently one of the most effective methods of educating pupils. Although it is more often applied in informal education, its popularity and importance are gradually growing within the traditional school system. Essentially, it is the effective use of a completely natural life process that accompanies everyone from early childhood through both positive and negative experiences, gradually shaping the behaviourand experiences of each individual[1,2].

According to the Association for Experiential Education [3] **experiential education (EE)** is a teaching philosophy that informs many methodologies in which educators purposefully engage with learners in direct experience and focused reflection in order to increase knowledge, develop skills, clarify values, and enhance individuals´ capacity to contribute to their communities. There are five

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common teaching approaches to promote experiential learning - active learning, problem-based and inquiry-based learning, project-based learning, service-learning, and site-based learning. Although each approach uses different ways of doing activities, they share features such as hands-on activities, cooperative learning, real-life problems, dialogue, questions, and/or interactions with others [4]. Hanuš et Chytilová [5] understand experiential pedagogy as a theory of "education through experience" or "education through living". This means effectively using the natural life process that accompanies us from early childhood through various experiences, which gradually influences our behaviour and experiences. According to Čapek [6], it cannot be confused with leisure or other primarily non-educational techniques.

In EE, pupils gain real-life experiences through their own activity and experience and learn spontaneously. It finds application, for example, in the teaching of natural sciences, when the teaching takes place directly in nature [7]. The emphasis is placed on the combination of personal experiences with more active problem-solving during lessons, helping pupils transform these experiences into practical insightsthrough reflection, thus contributing to a deeper understanding of the subject matter. This approach also shapes attitudes and prepares them for future life challenges. In addition to professional knowledge and skills, social abilities, mutual interaction, and collaboration are also important. The teacher accompaniespupils through the entire process, guiding them in achieving results and in thinking about the procedures that lead to them. Thuspupilsbecome more responsible for their learning [8].

The advantages of experiential education compared to traditional teaching methods are as follows:

- activates pupils throughout the entire lesson,
- prevents aimless playing by using all parts of the cycle,
- faster and more permanent acquisition of knowledge and skills,
- the acquired experience effectively supports the all-round development of the individual, as well as the development of the pupil's emotional intelligence, self-knowledge, personality development, creativity, spontaneity and critical thinking,
- support of team cooperation, positive behaviour and the creation of new ways of thinking and knowing,
- helps to improve pupils' relationship with school and subjects,
- facilitates the entry of school graduates into practice,
- motivates lifelong learning [8-11].

Experiences are unique and cannot be shared, as everyone experiences them individually [10]. They may not always have to be positive, but have to be intense enough. If we actively involved in situations, make decisions, and take further action, the experiences are more lastingand thanks to this we remember individual situations much better and can recall them again. That is why this method is particularly useful in situations where we want to provide pupils with an experience they have never had before [12]. An essential part of experiential learning is ongoing reflection, usually in the form of group discussion with strong emphasison critical thinking, aimedat analysing and evaluating the overall or current experience. Experience also enables the desirable strengthening of relationships between pupils [2].

In experiential learning activities, **motivation** and **key competencies** play a key role, which affects both activity and learning. Therefore, it is essential to support and develop them. Motivation can be enhanced in several ways, such as creating a pleasant atmosphereor introducing an element of mystery where participants do not know what will happen next. Alternatively, one can create an exciting story and set challenges with rewards, which encourages competition and effort among participants, since only one can win and anyone can become a winner [13]. The student is encouraged to go beyond his comfort zone (physical or psychological) to overcome himself, but always under the safe guidance of a teacher. EE focuses on creating challenges and positive stress (a person is capable of more than he thinks - few people realize what great achievements can be achieved through mutual

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help and cooperation). Skills and attitudes such as social learning (self-awareness, cooperation), soft skills (teamwork, leadership, communication and relationship skills), life attitudes (tolerance, responsibility), and problem-solving skills (critical thinking) are all developed through this process[10]. **Key competencies** are the real knowledge and skills that pupils need for their lives and which can be effectively developed throughEE. These include coherent speaking, working independently with the text, preparing effectively for lessons, planning your work correctly. A tool for measuring progress in key competences among pupils is assessment with feedback, which allows us to measure the fulfilled goals or how close we have come to them. Experiential learning, key competences, and assessment are united by the same methodological approach (Figure 1):

- **Needs analysis** – determining what we want to focus on and why, identifying problems in terms of competences, determining what needs to be evaluated, and planning the involvement of experiential pedagogy,
- **Setting specific goals** – for example, what we want the children to take away from the activities, what competencies we want them to learn, and how will we evaluate these aspects and use the experiences,
- **Activity implementation** - the correct choice of activities, their practical assignment and extracting lessons from them is a methodological process with its own principles, which should always be carefully considered in advance,
- **Reflection** – focusing on what the children have learned, what competences they have developed and in what way, how the experiential learning method worked, and what took place in order to have a basis for evaluation[12].

Fig. 1 Methodological principle of experiential learning [12]

EXPERIENTIAL EDUCATION IN THE INSTITUTE OF INTEGRATED SAFETY

The Faculty of Materials Science and Technology of the Slovak University of Technology, located in Trnava, is one of the seven faculties of the Slovak University of Technology. Its mission is to develop itsstudent's competencies and to carry out research with significance for the practical world in the 21st century. Faculty is committed to sustainably creating, disseminating and preserving knowledge and collaborating with others to bring new knowledge that creates positive challenges to society. It is dedicated to providing its pupils with an education that combines rigorous academic study and the excitement of discovery with the support and intellectual stimulation of a diverse community. The effort is to develop in every member of the faculty community the ability and passion to work wisely, creatively and effectively for the development of humanity [14].

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The Institute of Integrated Safety (IIS) is one of the six institutes located at the faculty. providing accredited education at all three levels of higher education in the Integrated Security study program. The IIS has long focused on the use, promotion, consultancy, and exploration of new possibilities for renewable energy sources and their environmental impacts [15]. Furthermore, itplays an active role in promoting itself at various events, such as DOD, Night of researchers, Where to Study, JOBDAY, Learning Trnava and others.The IIS organises internships and is responsible for the practical aspect of the Secondary School Professional Activity programme, enabling high school pupils to gain hands-on experience in the institute's laboratories. In 2023, we decided for the first time to organise experiential learning for pupils at *Kornel Mahr Primary School* in Trnava.

METHODS

As part of experiential learning, which took place in laboratories at the Institute of Integrated Safety, three classes of the seventh-grade pupils from*Kornel Mahr Primary School* in Trnava participated. There were 18-23 pupils aged 11 to 12 years in each class. In the 2023/2024 school year, they added a new subject - chemistry, taught by a teacher with a qualification in chemistry education.

The curriculum for the chemistry subject is developed in accordance with the requirements of the updated State Education Standard (uSES). According to uSES, the chemistry subject is focused on research and practical activity, where pupilsexplore the properties of substances, the laws of their behaviour and mutual interaction through experiments and their own investigation. The content is based on situations, phenomena, and activities that have a chemical basis and are comprehensible for pupils and important in the everyday life of a person. By conducting their own "scientific" activities, pupils acquire important skills, especially the ability to objectively and reliably observe and describe the observed. Pupils measure, record, sort, analyse and interpret the obtained data, form and verify test hypothesis, and draw conclusions. The goals of the chemistry subject are as follows:

- pupils will become familiar with basic knowledge of substances important for lifeand understand chemical phenomena and processes,
- they use technical terminology to describe chemical phenomena and processes,
- they understand the instructions for the implementation of practical activities and be able to carry them out according to the instructions,
- they plan and implement observations, measurements and experiments,
- they process and evaluate data obtained during observation, measurements and experiments,
- they develop manual skills, intellectual and social abilities through student experiments,
- they learn and apply the principles of safe handlingof substances,
- they search available sources for knowledge about the use of various substances in industry, agriculture and in life in terms of their importance for humans, their impact on the environment and human health,
- they use the knowledge and experience gained in the subject of chemistry to protect health and the environment [16].

During the experiential learning activity at the IIS, the pupils and their teacher covered topics such as pure chemical substances and their mixtures, the composition of substances, mixtures and solutions, expressing the composition of solutions through mass fraction and mass percentage, as well as the separation of individual components from mixtures using various chemical methods.

Within the concept of our EE, we have chosen a structured and targeted approach. At the beginning, the pupils received a brief introduction to the basics of chemistry, including its importance in human lives and nature, its goals and the subject of research. Subsequently, they became familiar with the basic principles of good laboratory practice and compliance with safety instructions, which are necessary for the safe conduct of experiments in a chemical laboratory. This systematic approach

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enabled pupils to acquire the necessary theoretical knowledge and practical skills crucial for successfully mastering laboratory tasks and laboratory work methodology.

The main topic of the theoretical part of experiential learning focused on the preparation of mixtures and the separation of their individual components. Through a presentation followed by a brief discussion, the concepts of chemically pure substances, mixtures and solutions, as well as their chemical composition, were discussed. The pupils provided examples of different types of mixtures and solutions they normally encounter in everyday life, thus proving their under standing of the subject and their ability to apply this knowledge in real-life situations. At the end of the theoretical part, the basic chemical procedures most commonly used in laboratories were introduced, such as weighing on laboratory scales, measuring the volume of liquids using a graduated cylinder, preparing homogeneous and heterogeneous mixtures, and separating components. The students had the opportunity to practice these procedures during the hands-on session.

The practical part was divided into two main areas, both conducted by pupils under the supervision of university teachers:

- **part -**chemical experiments were carried out in a chemical laboratory and divided into fivedistinct tasks (preparation of heterogeneous mixture, filtration, evaporation, separation, and dye adsorption from aqueous solution).
- **part** –burning of substances was carried out in a laboratory and divided into three distinct tasks (the combustion of liquids, solid substance, and dispersed powder).

CHEMICAL EXPERIMENTS

A. preparation of heterogeneous mixture -pupils prepared a heterogeneous mixture of water, table salt (sodium chloride NaCl) and sand (silicon dioxide SiO_2) using basic laboratory equipment - laboratory scales, a plastic spoon, a glass beaker, a glass stirring rod, a measuring cylinder, and a syringe. First, they weighed the required amount of salt and sand on laboratory scales, placed it into a beaker. They measured 150 ml of water in a measuring cylinder, added it to a beaker containing salt and sand, and mixed the solution with a glass rod (Figure 2 and 3).

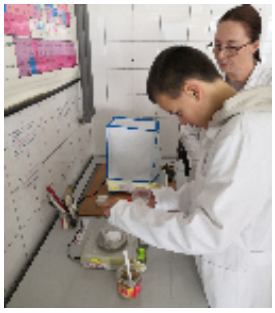

Fig. 2 Weighing of salt and sand on laboratory scales by a pupil

Fig. 3 Mixing the heterogeneous mixture in a beaker with a glass rod

B. filtration -the pupils separated the sand from the heterogeneous mixture by filtration, using a rack, a filter funnel, filter paper, a beaker, a glass rod, a syringe with distilled water, an evaporating dish, an electric hot plate, and laboratory scales. After setting up the filtration apparatus, they poured the mixture throughthe filter paper and the residue of the mixture was rinsed from the beaker with a small amount of distilled water (Figure 4). The empty evaporating dish was weighed and its weight recorded. The sand caught on the filter paper was flushed with a small amount of distilled water from a syringe into the evaporating dish. The evaporating dish was placed on the electric hot plate to slowly evaporate the remaining water. After that, the evaporation dish was weighed and the weight of the filtrate (sand) was calculated according to the following equation:

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$$m_1 - m_2 = m_3 \quad (1)$$

where m_1 is the weight of the dried filter with filtrate [g], m_2 is the weight of the filter before filtration [g] and m_3 is the weight of the filtrate [g].

Fig. 4 Filtration of the heterogeneous mixture through the filtration apparatus

C. evaporation - the pupils had to separate the salt from the remaining homogeneous mixture by evaporation, using an evaporating dish, an electric hot plate, and laboratory scales. First, an empty evaporation pan was weighed on a laboratory scale. The mixture from the beaker was poured into an evaporating dish, which was placed on the electric hotplate and all the water was allowed to evaporate. After evaporation, the evaporatingdish was weighed, and the mass of the residue (salt) was calculated using the following equation:

$$m_1 - m_2 = m_3 \quad (2)$$

where m_1 is the weight of the dish with the vapor after evaporation [g], m_2 is the weight of the empty dish [g] and m_3 is the weight of mass of the residue [g].

D. separation -the pupils dealt with the separation of a mixture of cooking oil and water using a separatory funnel (Figure 5). For this task, they used a stand, measuring cylinder, beakers, glass rod, separatory funnel. First, the required volumes of cooking oil and water were measured,then poured into a larger beaker. The mixture was thoroughly stirred with a glass rod, thencarefully transferred into a separatory funnel placed on a stand. After a short time, two distinct layers formed in the separatory funnel - the upper layer was cooking oil and the lower layer was water. The valve on the separatory funnel was opened and the bottom layer was slowly drained until only a layer of oil remained in the funnel. The valve eventually closed.

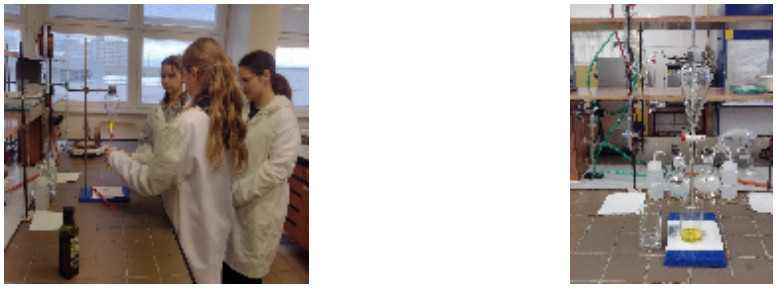

Fig. 5 The separation of a mixture of cooking oil and water using a separatory funnel

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E. dye adsorption - pupils could try removing dye from a homogeneous mixture using an adsorbent. All they needed for this task was a beaker, a plastic spoon and a watch. The desired amount of pre-prepared aqueous solution of methylene blue dye was poured into the beaker, which represented a homogeneous mixture. A small amount of adsorbent- activated carbon by a plastic spoon was added into the solution. The pupils watched how the dye was gradually adsorbed on the surface of the activated carbon and the intensity of the coloured solution slowly decreased. After some time, the solution became almost colourless, which meant that most of the dye had been removed (adsorbed).

BURNING OF SUBSTANCES

The second part of EEinvolvedpupils with fire experiments including types of burning, methods of extinguishing fires and the importance of safety and health protection in work and everyday life. They practically experienced the burning of substances of various states - solids (nitrocellulose), liquids (methanol, ethanol) and suspended dust.

A. combustion of liquids - thisexperimentinvolved observing the combustion of liquid alcohols, methanol and ethanol. These two simple alcohols have similar properties such as boiling point, appearance, and taste. When laboratory-gradealcohols are used for the experiment, they burn with a differently coloured flame. Alcohols contaminated e.g. with a small amount of substances, such as sodium salt, burn with the same flame. Adding a small amount of boric acid (H_3BO_3) causes methanol to burn with a green flame and ethanol with an orange-yellow flame. When performing this experiment, it is very important to observe strict safety measures (protective gloves, high-quality suction). For that reason, it was implemented only by a university teacher. The following tools were used for the experiment - Petri dishes, a fume hood, a metal spoon, a lighter, and a skewer. Two Petri dishes were placed in the fume hood, and the selected volume of alcohols was carefully poured into them. After igniting both dishes with alcohol, pupils could observe that both alcohols burn with a blue flame. After adding of small amount of boric acid to each dish of alcohol, the alcohols were ignited. Methanol burned with a green flame while ethanol with an orange-yellow flame. This difference is caused by the formation of an ester (trimethylborate) during the reaction of methanol with boric acid.

B. combustion of solid- the second combustible substance was nitrocellulose (cellulose nitrate). It is a highly flammable substance produced by esterification of cellulose by nitric acid and sulphuric acid. It burns with a very bright, odourless, yellow flame without any incombustible residue. A large amount of heat is released during the reaction. A ceramic bowl, a plastic spoon, a lighter, and a skewer were used for this experiment. A small amount of nitrocellulose was carefully taken into the ceramic dish with a plastic spoon. Subsequently, the nitrocellulose was ignited with a burning skewer. The reaction took place very quickly and intensely. From the point of view of safety, this experiment was also carried out by a university teacher.

C. combustion of dispersed dust -*Lycopodium clavatum*dust was burnt in a Hartmann tube. The Hartmann tube is a device for determining the ignition temperature of a layer of settled or dispersed dust as well as determining the minimum initiation energy. A dust explosion is a dangerous situation in industry, but also in everyday life. This experiment was first carried out by our doctoral student, and under his supervision, the pupils could try filling the Hartmann tube with a sample and initiating the test where the combustion of the dust took place (appearing like an explosion due to the speed) (Figure 6a).

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Fig. 6The burning of dispersed powder in the Hartmann tube (a) and the presentation of different types of extinguishing agents (b, c)

These experiments not only demonstrate various aspects of combustion and safety measures but also provide practical experience in chemical safety and experimental research. At the end, the pupils were informed in detail about different types of fire extinguishers and extinguishing agents (Figure 6 b,c). The collective of the department of fire engineering explained to them in detail the specific use of individual types of extinguishing agents and devices for different categories of fires, as well as the correct procedure for their application. Even though the pupils did not have the opportunity to practically try out the use of fire extinguishers, they acquired basic theoretical knowledge that is necessary for the correct and safe execution of fire extinguishing in real situations.

RESULTS

Short interviews were conducted with the pupilsboth immediately after the EE as well as after a period of time. The initial feedback was very positive, with pupils expressing enthusiasm for their visit toa universitychemical laboratory, which was a new and exciting experience for them, because their primary school does not have such a specialized classroom. The pupilsreported that they understood the theoretical explanations and knew what to do during the practical part. EE helped them better connect theoretical knowledge with practical life (weighing, volume measurement). What fascinated them the most was the opportunity to conduct chemical experiments themselves and use laboratory equipment. For example, they were very surprised that different states of substances can burn, as well as the fact that even dust can burn. Some pupils also appreciated the teamwork required during the experiments, highlighting the collaboration and mutual assistance in achieving common goals. However, there were some minor gaps in their understanding, particularly regarding the application of chemical experiments in nature and their environmental significance.This educational program significantly enriched their learning experience. They expressed a desire to visit the institute again next school year to try more experiments. In addition to the experiments, they were also excited about the professional environment of the laboratory, where they could work with laboratory equipment that they usually only see in textbooks or on television.

A structured interview was conducted with the teacher who alsoprovided feedback via a questionnaire. The teacher considered the experiential learning to be extremely beneficial and varied. She particularly highlighted the connection between theory and practical examples. During practical sessions, she noticed that this form of teaching was very suitable for the pupils, because they had the opportunity to try out laboratory procedures and tools in real life. This allowed them to work more freely without restrictions. The pupils were enthusiastic because they had more space and opportunities for practical activities. The teacher mentioned that during regular chemistry lessons at school, she performs the experiments while the pupils are just spectators, which leads them to be inattentive, disruptive and distracted. Furthermore, the school also does not have the same laboratory equipment and conditions as in universities, which significantly limits the possibilities of practical teaching. She also evaluated the effectiveness of experiential activities very positively. When covering new material later on, the next study, the pupils understood the material better, they were able to better

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connect theoretical knowledge with practical experience. Some pupils automatically switched to knowledge and information gained during the excursion. This progress was particularly evident when covering the topics of mixtures and separation methods, filtration and classification of substances according to combustion. Interviews conducted after several weeks revealed that the EE helped the pupilsnot only better understand chemistry but also other subjects like physics. They were better able to understand physical quantities such as weight, volume and their calculation, as they had the opportunity to weigh and measure exact volume during chemical experiments. EE clearly had a positive impact on the children's ability to understand and remember the curriculum, as they not only workedwith information but also experimented, discovered, and learned to work in groups, which helped them acquire more lasting knowledge.

The teacher would greatly appreciate an increase in the time allowance for chemistry lessons, e.g. from the current two to three lessons per week. She also agreed that similar excursions and practical experiments should become a regular part of chemistry education, as they allow pupils better to understand processes, knowledge and events in a simple and illustrative way (they become active and not just passive observers and recipients of information).

On the other hand, however, she pointed out that the pupils did not yet sufficiently understand the connection between chemical experiments and environmental protection. For now, they perceive these aspects separately, as if they are unrelated to each other.The response to the question of whether the excursion and subsequent teaching increased the children's environmental awareness was negative. Only very few pupils were able to apply the knowledge from the excursion to real-life situations related to environmental protection. Finally, she added that the pupils were enthusiastic and would like to participate in such activities more often, either in our laboratories or in other areas of the faculty. She would definitely recommend to other teachers not to hesitate and to take advantage of any opportunity and cooperation to introduce similar excursions into their pedagogical process. She would also welcome the strengthening of chemistry lessons directly at the school.

DISCUSSION

The key to the active and meaningful involvement of pupils is the use of diverse teaching methods, which are the basis of motivation and overall development. In today's educational process, it is no longer enough for the teachers to pass onjust knowledge; they must present it in a way that interests the pupils. Although the preparing experiential activities can be challenging for teachers in terms of time, space, personal commitment and often finances, these activities are attractive to pupils due to their novelty and unconventionality, which motivates entire groups of children. Interesting experiences that pupils experience first-hand create lasting memories that have a much greater impact than just learned lessons and definitions [8].

Compared to traditional teaching methods, which focus mainly on theoretical explanation, the EE provides pupils the opportunity to be directly involved in the learning process. This approach not only increases their attention and interest, but also significantly contributes to better memorization and understanding of the subject matter. By linking theory with practice, pupils are better able to apply the acquired knowledge in real situations. EE has a positive effect on long-term knowledge retention. Since pupils have the opportunity to try directly different procedures and see the results of their experiments, these experiences help them to better remember the subject matter and apply it in the future. Thus, experiential learning becomes not only a tool for a better understanding of the current curriculum, but also a basis for future learning.

It also increased pupils' motivation to study chemistry and natural sciences. A greater willingness to engage in discussions, ask questions and actively participate in experiments was observed. This increased interest could lead to better academic results and a greater willingness of pupils to continue studying natural sciences. As part of the feedback, the pupils expressed their satisfaction and enthusiasm for the opportunity to participate practically in the lessons. Many of them said that experiential learning helped them better understand difficult topics and that they would

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welcome more such activities. This positive feedback from pupils confirms the effectiveness of this form of teaching.

CONCLUSION

Experiential pedagogy is an effective and innovative approach to teaching, applicable in both formal and informal educational settings. Although the preparation and implementation of experiential programs or activities can be time-consuming, their benefitssuch as active student engagement and skill development, are obvious. EE not only contributes to the acquisition of knowledge and skills, but also to the development of the overall personality. It is crucial to always clearly define the objectives of the program to avoid distractions on too many aspects at once and to focus on group dynamics and cooperation.

In the future, we would like to implement experiential learning focused on environmental processes. A significant motivation for this is also the fact that, based on the primary education reform, environmental education will be a mandatory part of the educational curriculum at primary and secondary schools. According to the survey, environmental education was part of the content of some subjects in 53% of primary schools, while it was taught as a separate subject in only 5% of primary schools. The situation is better in grammar schools, where up to 77% incorporate environmental education in various subjects. In the upcoming school year, the introduction the subject of environmental education should already be mandatory and should be implemented precisely through experiential learning and various activities directly in nature, projects in the local community, independent research and experiments aimed at improving the environment. Children should be encouraged to develop environmental awareness and actively solve environmental problems. Professional discussions between pupils and pupils' reactions to counterarguments should also be part of the teaching. Given the alarming consequences of the climate crisis and environmental degradation, it is important to educate children about these topics and show them how they can influence the future of their communities and the planet. Planned activities and practical exercises would be aligned with the curriculum of this subject in elementary schools.

In the following school year, we are planning to come up with experiential chemistry education for the eighth grade pupils of *Kornel Mahr Primary School*again, focusing, for instance, on chemical reactions. We would also like to reach out to other nearbyprimary schools located such as *Bottova Primary School* and *Andrej Kubina Primary School*, to offer similar programs.

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REFERENCES

[1] Bolick, C. M., Glazier, J. & C. Stutts. (2020). Disruptive Experiences as Tools for Teacher Education: Unearthing the Potential of Experiential Education. - *J. Exp. Educ.*, vol. 43, no. 1, pp. 21–36, 2020, doi: 10.1177/1053825919877212 .

[2] Herink, T., Bělohlav, V., Jirout, T. & Z. Bělohlav. (2022). Opportunities of experiential education in chemical technology and engineering. - *Educ. Chem. Eng.*, vol. 41, no. September, pp. 32–41, 2022, doi: 10.1016/j.ece.2022.08.003.

[3] Association for Experiential Education,. What Is Experiential Education? - Experiential Education.- Available on internet: https://www.aee.org/ .

[4] Kuo, N. C., Kawaguchi, T. & Y. F. Yang. (2021). Exploring Absolute Happiness Through

Recenzovaný zborník vedeckých prác • Proceedings of scientific works
Edition ESE-63 • ISBN 978-80-570-5441-2
Bratislava: Slovak Society for Environment, Slovak Republic

Experiential Education. - *J. Exp. Educ.*, vol. 44, no. 4, pp. 346–362, 2021, doi: 10.1177/1053825920975141.

[5] Hanuš, R. & L. Chytilová, (2009). Zážitkově pedagogické učení. - Praha: Grada, 2009, 192 s. ISBN 978–80–2476–909–7

[6] Čapek, R. (2015). Moderní didaktika: lexikon výukových a hodnoticích metod. - Praha. Grada. 2015. ISBN 978-80-247-3450-7

[7] Severini, E. (2021). Sebaregulácia učenia sa v prírodovednom vzdelávaní. - no. August, 2021, pp. 309–325.

[8] Tkáč, K. (2014). Zážitkové vyučovanie v edukačnom procese. 2014.

[9] Miska J.W. *et al.* (2022). How do undergraduate engineering students conceptualize product design? An analysis of two third-year design courses. - *J. Eng. Educ.*, vol. 111, no. 3, pp. 616–641, 2022, doi: 10.1002/jee.20468.

[10] Vanková, K. (2018). Metódy zážitkovej pedagogiky a ich uplatňovanie vo výchove mimo vyučovania. - *Vychovávateľ*, vol. 9–10, pp. 1–17, 2018.

[11] Yao, J. (2023). Exploring Experiential Learning: Enhancing Secondary School Chemistry Education Through Practical Engagement and Innovation,"*J. Educ. Humanit. Soc. Sci.*, vol. 22 pp. 475-484, 2023, doi:10.54097/ehss.v22i.12508.

[12] Slejšková, L. (2011). *Škola Zážitkem*.

[13] Knotková, A. (2022). *Zážitková pedagogika*. - 1. vydání. Hradec Králové: Gaudeamus, Hradec Králové, Czech republic, 2022.

[14] Čambál, M. (2019). Dlhodobý zámer MTF STU na obdobie 2019-2024. - Available on internet: https://www.mtf.stuba.sk/sk/fakulte/dlhodoby-zamer-fakulty.html?page_id=6960

[15 Ústav integrovanej bezpečnosti. Available in internet: https://www.mtf.stuba.sk/sk/ustavy/ustav-bezpecnostneho-a-environmentalneho-inzinierstva.html?page_id=3112

[16] Vzdelávací štandard pre 2. stupeň ZŠ. Available in internet: https://www.minedu.sk/vzdelavacie-standardy-pre-2-stupen-zs/