Mining and its Environmental Impacts in the Process of Geographical Education in the Context of Sustainable Development

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ABSTRACT

Aim. The aim of the study is the proposal of didactic activities that can be used in the teaching process of the geography with possibilities of interdisciplinary penetration. Based on these activities, students can take a critical approach to solving problems of nature and landscape protection.

Methods. The teaching methods were adapted to the revised Bloom's taxonomy of goals, while mainly classical general didactic teaching methods were used: interpretation method, information-receptive method, heuristic method. Innovative methods included the EUR learning and thinking strategy, brainstorming and quickstorming.

Results. With the proposed activities, we point to the need to implement scientific knowledge into the teaching process because the content of geography also focuses on the links between the country and human society, using the example of mining.

Conclusion. Historic, but also contemporary places with a high intensity of mining, whether it is the mining of mineral raw materials or the production of wood, represent ideal model territories for complex geographical education with a high interdisciplinary character and the connection of interdisciplinary relations from other scientific disciplines. Therefore, the proposed activities are a suitable tool.

Keywords: environmental impacts of mining, training and education, fieldwork, project teaching, didactics of geography.

Introduction and Methods

Every mining project brings with it positives and negatives. Currently, the basis of mining is sustainable development, which should strive to restore the ecosystems in which mining is carried out. However, everything depends on the method of mining, i.e. whether it is surface mining or deep mining. Surface mining threatens the degradation of agricultural land and the overall transformation of the relief, when clear traces and new forms of anthropogenic relief remain in the terrain (e.g. leveled or terraced agricultural areas, road embankments, fallout and heaps). In the country, e.g. as various forms of depressed structures, remnants of mining rock dumps. During massive mining, air pollution occurs with various gases emitted from the technical means used in mining, when the intensity of air dust and noise increases. It is also important to point out the positive aspects of mineral mining from the perspective of regional development. It is the localisation of mining that creates job opportunities in a given region, as well as new infrastructure along with new retail chains (Wittlinger & Šolcová, 2018). Deep mining risks the creation of sinkholes, degradation of slopes and erosion of the soil cover. This is primarily the pollution of the rock environment by anthropogenic intervention, when there is a risk of dangerous substances leaking to the surface, or into the surrounding rock environment.

It is also important to draw attention to the extraction of wood, the geography of forestry, areas of the wood processing industry, methods of extraction and processing of wood.

From this aspect follows the need for each individual to build knowledge, on the basis of which he is able to understand every impact of human activities on the environment and to form the right attitude, which is necessary for the creation

of healthy conditions for the existence of life and the development of society. As part of geography education, students should acquire knowledge, experience and competences to be aware of their own environment, in which they live depending on their existence (Wittlinger et al., 2020). Comprehensive geography education includes the importance of developing future researchers, capacity building and strategic planning (Bednarz et al., 2013).

David Lambert and John Morgan (2011) as well as Henrich Grežo and František Petrovič (2019) raise major questions about how understanding of global sustainable development issues is taught in schools and suggests that a more critical approach is needed in the teaching of geography in schools. The authors state that it is necessary to consider what knowledge and understanding of development is offered to students through geography, which is one of the key sources of knowledge about the problems of predicting the further development of the landscape sphere. Complex geographical education is also important in the adequate preparation of students for secondary school, or professional university studies with a focus on Earth sciences.

The implementation of the issue of mining in the teaching process is currently very important. Based on specific didactic activities, students can understand the importance of mining in relation to the environment. The choice of teaching methods should be based on the revised Bloom's taxonomy of goals, while it is important to also use classic general didactic teaching methods: interpretation method, information-receptive method, heuristic method and innovative methods, such as EUR (Evocation — Awareness — Reflexion) learning and thinking strategy, brainstorming and quickstorming. In the teaching of geography, we also focus on the modern concept of the teaching process — project teaching.

Impact of Mining on the Environment

Extraction of mineral resources significantly contributes to economic growth and economic development in most countries of the world. Findings from a study (Albert et al., 2015) in Ghana (Africa) showed that mining activities deplete environmental resources such as water, soil, vegetation and overall ecosystems. The authors concluded that mainly the rivers in the region and, to a lesser extent, the soil in the areas surrounding the mines are polluted, which is susceptible to increased erosion and loss of viability for agricultural purposes, which has a negative impact on crop production.

Before the development of human society, our planet was covered by 60 million km2 of forest (Waring & Running, 2007). As a result of deforestation, there are currently less than 40 million km^2 (Food and Agriculture Organization, 2022 as cited in Bologna & Aquino, 2020). The intensification of forest management and the change in the way of management in which logging takes place is one of the factors that significantly affects the limit of spatial expansion of forest

ecosystems on Earth. Currently, climate change associated with deforestation is among the limiting factors. Large-scale removal of vegetation cover (tree floor) and climate change are interconnected, and solving them is key to sustaining life on Earth. In recent decades, the debate on climate change has gained global importance with the consequences caused by human activity: among them, water and air contamination (mostly the greenhouse effect) and deforestation are the most mentioned.

The Implementation of Mining in the Educational Process

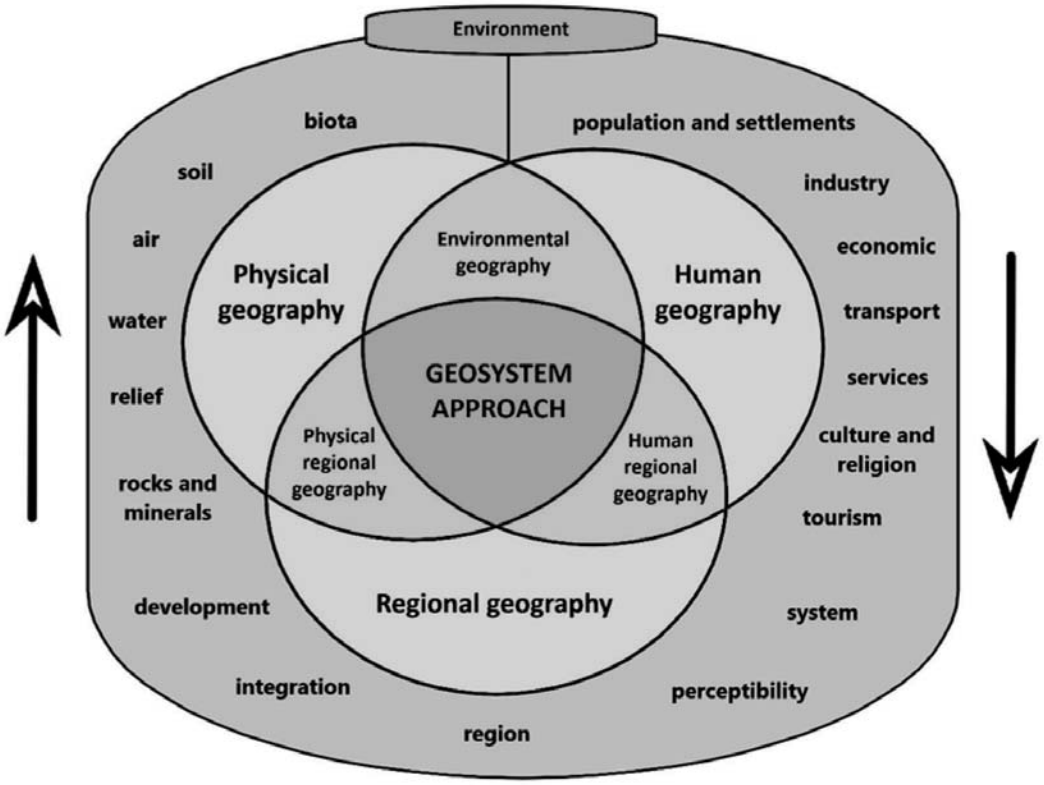
The implementation of the issue of mining within the teaching subjects at all types of schools is not so simple. It is not possible to include a separate teaching subject dedicated only to this topic in the educational process within the lower level of education. Therefore, it is included in related subjects.

Mining and its impacts on the environment are not directly implemented in the State Education Program (Slovakia), but are included in it as geological topics that partly follow on from mining issues. Within Biology (8th grade, International Standard Classification of Education **(**ISCED) 2), the subject of learning is exclusively non-living nature. Part of the subsequent knowledge is included in the Geography curriculum (8th grade, ISCED 2), where the geological structure of Slovakia is covered in the lessons. Geography also provides knowledge about the world's deposits and accumulations of mineral resources. Some knowledge from mineralogy and crystallography is included in chemistry, and rarely information about non-living nature also appears in physics. In grammar schools (4th year of study, ISCED 3A), the geography curriculum is focused on the lithosphere, the basis of which is knowledge of the structure of the earth's body, the basic units of landmasses, the movement of lithospheric plates, the functioning of endogenous and exogenous processes and their influence on the formation of the earth's surface (Turanová & Ružek, 2015).

Why geography as a teaching subject? Alena Dubcová et al. (2012) understands the landscape as the living space of all of us, and although the landscape is also studied by other scientific disciplines (non-geographical), in its comprehensive study geography has a dominant position — science at the intersection of natural, social and technical sciences. Geography integrates and applies knowledge from these sciences to space, which gives knowledge a qualitatively new "geographical" dimension. One of the tools of geographic education is the geosystem approach, which teaches students to understand the context and relationships between the individual components of the landscape sphere (see Figure 1). Within the framework of landscape research and land use, intersubjective relationships are important, which were addressed by Dusan Vallo et al. (2019).

Figure 1

Comprehensive geographical education: the optimal balance between physical, human and regional geography



Source. Own figure.

It is important to realise when teaching the issue of mining that it is a topic that is directly connected to the use of natural resources. For this, it is necessary to know the basic physical-geographic conditions within the individual regions of the world. Students draw knowledge from several geographic subdisciplines of physical geography, such as lithogeography (rocks and minerals), morphogeography (relief), hydrogeography (water), climate geography (atmosphere), pedogeography (soils) and biogeography (vegetation and fauna). When students have a general overview of physical regional geography, they can begin to acquire knowledge of human geography, where they understand the principles and laws of spatial expansion of human activities — demogeography (population, structure for example of religion) (Judák, et. al., 2023; Králik et. al, 2022), urban geography (settlements), geography of the production sphere (industry, agriculture, forestry and fisheries) and the geography of the non-production sphere (transport, services, tourism) (Roubalová et. al., 2022). If this knowledge is connected, we get into environmental geography and can define the basic influences and impacts of human activities on the environment.

Mining of mineral raw materials and wood is concentrated within the production sphere of industry in the economy. The sectoral structure of the economy ranks mining in the primary sector — the geography of industry.

Didactic Aspects of the Educational Process

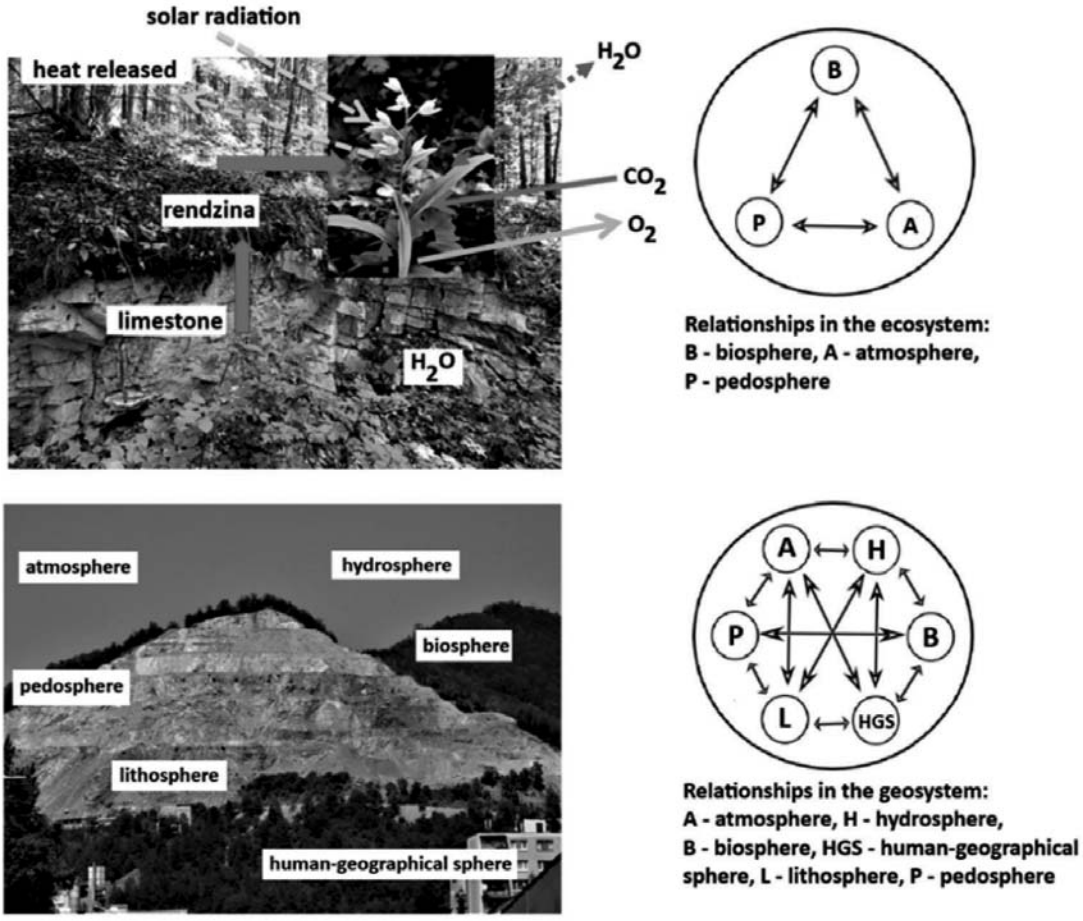
In the theory and practice of the teaching process, the issue of methods plays a key role, because the orientation of the teaching process, the activity of the teacher and students, and thus also success in achieving goals, depends on its solution (Anderson & Krathwohl, 2001; Bánesz & Hašková, 2020; Turek, 2014). Currently, problem-based methods are preferred, which are designed to develop critical thinking skills through a problem-based task, or situations when the teacher organises a teaching cognitive process using various information sources, e.g. didactic films, statistical data, graphs, tables with numerical data, periodicals, etc. Cognitive processes can consist of analysing, explaining, evaluating, comparing and drawing conclusions (Chomiak-Orsa & Golusińska, 2018).

If the local country allows it, then it is advisable to choose different organisational forms of the teaching process, such as a trip and an excursion. Katarína Úradníková and Hilda Kramáreková (2016) understand the local landscape as that part of the real world that surrounds students from early childhood, so geographical knowledge is very closely connected with practical life. It is precisely in the teaching of the geography of the local landscape that the teacher must place emphasis on affective goals, and through them the students' cognitive goals will also be consolidated and fulfilled. Dubcová et al. (2012) considers teaching in the field to be an integral part of the educational process of geography, which significantly contributes to the attractiveness of geography. Walks, excursions, work in the field make it possible to develop cooperation not only between natural science and social science disciplines, but also to use classic and alternative teaching methods (e.g. project teaching, integrated thematic teaching).

Here it is important to realise the irreplaceable role of teaching geography. The current digital age, the method and availability of information acquisition complicates the work of teachers more and more. Students thus show less interest in the teacher's knowledge and information. Therefore, it is very important that the current teacher is creative and prepares didactic activities and non-traditional teaching methods for his students, as well as introducing Information and Communication Technologies (ICT) (Grežo & Jakab, 2014; Jakab et al., 2016; Jakab et al., 2017).

Rene Van Berkel (2000) and Ľubica Lukianenko et al. (2008) consider it important to support research and education in the field of mineral extraction in order to increase the understanding and importance of a specific location and thus build support for its protection, which will allow students, but also the wider public, to interact with geology, ecology, industry, industrial heritage and environmental studies. Some accessible locations, either quarries or outcrops in the relief, are suitable model areas for students to familiarise themselves with the differences in the ecosystem and the geosystem. Students can thus understand the functioning of the landscape sphere (geosystem) and its subsystems of the physical-geographical and human-geographical spheres, where constant flows of energy and matter take place dynamically (see Figure 2).

Figure 2
General model of ecosystem and geosystem



Source. Činčura, 1983, edited by authors.

Selected Didactic Activities

As part of didactic activities, it is currently important to focus on the development of reading and financial literacy in the teaching process, including the students' professional knowledge. As part of reading, we used a strategy to develop students' communicative competence and reading literacy through worksheets focused on reading comprehension. Students currently need to be guided to independent work with professional and scientific texts. It is advisable to use such a strategy especially when creating independent seminar work. In our case, it was the work Microgeography — the landscape around us. Students worked with internet resources, learning to distinguish relevant text and rationally argue whether the given content is true. The goal of such an independent activity of the students is to teach them to work with maps and to interpret their content to their classmates.

After submitting the work, it is necessary for the students to present their work and develop their communication skills. Students thus have more space for their own creation of vocabulary (professional terminology) and language expressions (ability to communicate in spoken or written form, ability to present their thoughts, opinions and attitudes and know how to support them discursively).

The development of financial literacy in the educational process should also be included in the issue of mining. Students can thus work with various statistical data, either within selected regions of the world or within national databases. In such work activities, it is also appropriate to work with cartographic outputs that are publicly available (e.g. Global threat to life, Ecological footprint, Economy — mining and industry, Mining — share of GDP, etc.). Students can thus compare individual economic disparities of regions, analyse different localisation assumptions for use in a given sector of the economy. The main goal of such activities is to acquaint the students with the indicators of the given states, which tell about their cost of living and the prices of various commodities in individual states, respectively how much raw materials are mined in a given state — in some states, mineral extraction is an important source of income (Kolenčík et al., 2012; Kolenčík et al., 2014).

Name of the Activity: The Landscape Sphere: A Unique Geosystem from the Perspective of Regional Geography

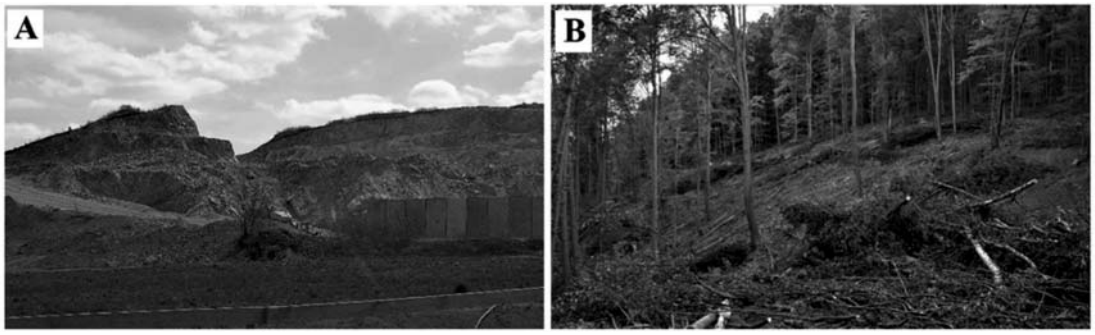
Goal: students should acquire concepts, facts and principles from various scientific disciplines of geography. A partial goal of the activity is also to understand that geography is not a science that provides us with information about different countries of the world, but is primarily a science that teaches us to think geographically, understand in context and understand the relationships between individual components of the landscape sphere. Age group: high school students (16-17 years). Tools: geographic atlases, school textbooks and exercise books, recommended websites to national and international databases. The activity procedure: students have the task of creating a project, the task of which is to choose any region within the continent or the world and thus present in the form of a conceptual map the basic physical-geographical and human-geographical conditions with a focus on mining in the given region. It is recommended to choose regions with a strong predominance of the mining industry in order to display and explain the relationships of long-term socio-historical development, connections between natural, social and technical phenomena.

Name of the Activity: Microgeography—the Landscape Around us

Goal: to teach students to work with relevant literature, but also with various Internet resources. Another goal is to teach students to write professional texts, select information and work with it, as well as present it. Age group: high school students (16-17 years). Tools: sources of historical information for each municipality individually, sources of current information (municipal monographs, files, PHSR [Economic and Social Development Plan]), documents, communication with relevant public administration authorities), geographical atlases, recommended websites for national and international databases. The activity procedure: the students' task is to implement their global thinking and knowledge at the local microgeographical level within a specific state. Everyone's task is to choose one municipality with a significant mining industry (urban or rural seat) and elaborate its complex geographical characteristics in the form of a seminar paper and create a project for it, which will present the basic natural and socioeconomic specifics of the given municipality with a focus on selected mining problems (see Figure 4). Students should have enough time (min. 2 months) to prepare, with the condition of using relevant literature, but also various internet sources.

Figure 3

Significant impact of mining in the country at the local level



Source. Own photos.

Name of the Activity: Deforestation and the Environmental Impact of Mining in the World

Goal: apply strategies for the development of creative and critical thinking through the use of various information sources (except textbooks), guide students to deduction, concretisation, use categorisation (classification - classification based on a certain criterion), guide students to graphical representation of the curriculum (concept maps, handouts, tables, graphic representations). Age group: high school students (18-19 years).

Tools: sources of historical information for each municipality individually, sources of current information (municipal monographs, files, PHSR, documents, communication with relevant public administration bodies), geographic atlases, recommended websites for national and international databases. The activity procedure: from the online database available on the website of the Food and Agriculture Organisation, students should obtain information about forestry production and wood trade in the world (production, export, import). The data from the database will be interpreted by the students in a tabular form and they will show the changes in mining shares in the form of graphs. Subsequently, they will cartographically show the above 3 indicators in the world using the cartogram method. For which they will develop an overall analysis, in which they should focus on the environmental-geographical aspects of the spatial differentiation of mining in the given states (continents) and thus point out the factors of environmental problems on a global level with examples (destruction of tropical forests, etc.).

An example of information resources that students can work with in the online space with the help of ICT. Subsequently, they can create tables, graphs, statistical analyzes from the obtained data, where it is necessary to draw conclusions based on the established methodology, which significantly contribute to the degradation of the environment. Table 1 provides an overview of basic information sources on individual topics focused on mining and its impact on the environment.

Table 1

Publicly accessible sources of information with a focus on mining (SK, CZ, World)

Topic	Title	Web	Source
Extraction of mineral resources	Slovakia's mineral resources	http://apl.geology.sk/temapy/	2017 ŠGÚDŠ, Esprit, s.r.o.
	Mineral deposits	http://mapserver.geology.sk/gpark	Gargulák et al., 2014, ŠGÚDŠ, Esprit, s.r.o.
	Traditional land use and traditional culture	https://app.sazp.sk/atlassr/	Podolák et al., 2002, 2002-2021 SAŽP
	Energy production and raw materials extraction	https://app.sazp.sk/atlassr/	Mládek, 2002, 2002-2021 SAŽP
	Mining — share of GDP	https://atlas.mapy.cz/?p=010000&s=1&id=tezba&n=m&z=2.3&x=0.000&y=7.450&m=m	1996–2020, Seznam.cz, a.s.
	Exclusive deposits of non-metallic raw materials	https://app.sazp.sk/atlassr/	Tréger & Baláž, 2002.

Topic	Title	Web	Source
	Exclusive deposits of energy and mineral resources	https://app.sazp.sk/atlassr/	Tréger & Baláž, 2002.
	Exclusive deposits of building materials	https://app.sazp.sk/atlassr/	Tréger & Baláž, 2002.
	Forest management information system	https://gis.nlcsk.org/islhp/#lesnictvo	NLC Zvolen, 2020
Extraction of wood	Summary information about the forests of Slovakia	https://gis.nlcsk.org/islhp/suhrnne-informacie	NLC Zvolen, 2020
	High-Resolution Global Maps of 21st-Century Forest Cover Change	https://glad.umd.edu/dataset/global-2010-tree-cover-30-m	Hansen, et al., 2013, Global Forest Watch System Status, 2021
Environment	Global threat to the environment	https://atlas.mapy.cz/?p=000001&s=1&id=globalni-ohrozeni&n=m&z=2.3&x=0.000&y=7.450&m=m	1996–2020, Seznam.cz, a.s.
	Ecological footprint	https://atlas.mapy.cz/?p=010000&s=1&id=ekologicka-stopa&n=m&z=2.3&x=0.000&y=7.450&m=m	1996–2020, Seznam.cz, a.s.
	Environmental and health indicators of Slovakia	http://mapserver.geology.sk/indikatory	Rapant et al., 2014, ŠGÚDŠ, Esprit, s.r.o.
	Partial monitoring system—Geological factors	http://mapserver.geology.sk/monitoring	Liščák et al., 2013, ŠGÚDŠ, Esprit, s.r.o.
	Environmental risk resulting from abiotic component pollution	https://app.sazp.sk/atlassr/	Rapant & Kordík, 2002, 2002-2021 SAŽP
	Forest care programs	https://gis.nlcsk.org/islhp/psl	NLC Zvolen, 2020
	Forest protection	https://gis.nlcsk.org/islhp/ochrana-lesa	NLC Zvolen, 2020
	Degree of forest damage according to tree species	http://datacube.statistics.sk/	ŠU SR, 2021
	Geological conditions	http://datacube.statistics.sk/	ŠU SR, 2021
	Reports on the state of the environment of Slovakia	https://www.enviroportal.sk/spravy/	2005-2021 www.enviroportal.sk

Source. Own research, edited by authors.

Conclusion

At the beginning of the study, we stated the need to implement geographical excursions and field trips, which have a significant impact on the knowledge level of students, or motivational character for a wider deepening of complex geographical knowledge. A geographical excursion is also an important tool for the implementation of field exercises, or field practice of future researchers and scientists. Antonius J. van Loon (2008), Hedviga Tkáčová et al. (2022), however, states that student fieldwork is being minimised in most countries, which is due to several development trends. The most important reasons are direct or indirect financial short-sightedness, ever-increasing population pressure, vandalism, and counterproductive legislation. Declining field experience poses a threat to the ability of future generations of Earth scientists to optimize exploration of all kinds of natural resources.

How should students come into direct contact with the unknown? Is the content of educational plans adequately set to eliminate the absence of field exercises, or excursions/field trips? A Canadian study (Stearn, 2019) points to the issue of insufficient preparation of high school students in the field of geology. It brings to the fore the improvement of the teaching of science subjects in secondary schools, while they should consider introducing geology as a matriculation subject where it is not available now. The current state of affairs raises concerns and the need for greater efforts to convey enthusiasm for new areas of research to the next generation. Here, geography clearly has an irreplaceable place. Its comprehensive geographical education can bring students closer to all parts of the landscape, teach them to understand natural laws, changes in human behaviour and the impact on the environment in the near future.

A Russian study (Guzhelya et al., 2020; Lisov, 2016) highlights the growing role of new scientific and technological achievements in mining, improving environmental and personnel requirements. Due to the fact that the leading schools in the mining industry, in addition to Russia, are being established in Canada, Germany, the USA, Australia, Great Britain, many developing countries rich in natural resources have begun to create their own national training centers in this field (Azizi et al., 2021; Khonamri, et al. 2021)

Within the teaching of geography, it is necessary to implement scientific knowledge in the process of complex geographical education. The pedagogical goal was the design of specific didactic activities, the result of which should be that students' can take a critical approach to solving problems of nature and landscape protection. Students should be able to classify sources of pollution within individual components of the environment and subsequently analyse the state and quality of the environment at several hierarchical levels (local, regional, continental, global). Thus, the content of geography focuses on the links between nature and human society. Part of the work is the proposal of suitable didactic activities in the teaching of geography with a focus on the influence and impacts of mining on the environment. The pedagogical problem of the research

is qualitative action research, in which we propose specific didactic activities in the teaching of geography and thus directly respond to the needs of practice. The activities are verified directly in the educational process on a selected sample of students. Their goal was to diversify the teaching of geography.

By teaching form we understand the organisational form of teaching, by which the teacher implements the teaching process using different methods in different environments. Currently, in the educational process, less and less emphasis is placed on understanding the physical-geographical and human-geographical relationships between the individual components of the landscape, therefore it is necessary to apply practical activities and exercises in the educational process of geography, which will enable students to create a better image of the country as a whole composed of smaller components that are connected to each other. It is necessary to choose suitable methods, means and forms of pedagogical work in relation to the individual and age-specific characteristics of pupils (Petrikovičová & Wittlinger, 2020). The theoretical orientation and synthesis of research in the given area is focused on general questions from the field of pedagogical research and the theory of teaching geography in the field, as well as increasing the effectiveness of teaching.

By proposing specific didactic activities, we point to the need to implement scientific knowledge into the teaching process. The activities are designed especially for high school students aged 16-19. They were verified as part of the teaching process on the subject of geography in various classes during the 2022/23 school year, some of the activities were also carried out during the Covid-19 pandemic. We can conclude that the activities are also suitable for virtual teaching. Students present their knowledge and experience in an interesting way. They thus have space to create vocabulary, mental maps and the opportunity to present their opinions and attitudes.

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