ONLINE TOOLS FOR GEOHERITAGE INTERPRETATION BOTH IN FORMAL AND INFORMAL EDUCATION

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Abstract
Geoheritage interpretation represents communication between information about geoheritage and tourists, resulting in the acquisition of knowledge, a change in attitudes, the creation of an emotional bond, and/or the provision of the experience itself. Both the chosen language of communication and the interpretation tool are essential to achieve education and satisfaction. Given today's modern times, online tools are a great intermediary for information at any given time or place. Tools such as websites, virtual tours, virtual laboratories, virtual galleries, interactive maps, posts on social media, online games, and many others can provide opportunities for both formal and informal education due to their versatility. This article showcases the opportunity to combine several of the aforementioned tools to achieve multiple goals a) in formal education by teaching geotourism, b) in informal education by educating the public through geotourism, and c) in science by conducting research. Such a proposal is the subject of an internal scientific project the output of which is an innovative educational platform enabling the virtual examination of rock formations with 360° views of rock samples, interactive elements, and educational modules. The nature of the proposal adds not only to its educational value but also to its research value, thus providing space for further development in this area.

Key words: geotourism, geoheritage, geointerpretation, online interpretation, geoeducation

Introduction
Geoheritage encompasses elements of geodiversity that are scientifically, didactically, historically, aesthetically or culturally significant for conservation and play a key role in understanding the origin and history of the Earth (UNESCO, 1999; Wimbledon & Smith-Meyer, 2012). These natural elements are increasingly recognized not only for their scientific value but also for their potential to environmentally educate general public. Geoheritage interpretation functions as communication by translating geoscientific information into language that is accessible and resonant with general public. Interpretation is however not just information transfer, it involves constructing meaning, engaging visitors emotionally and intellectually, and instilling an ethic of conservation to ensure that the interpreted information is understandable and enjoyable to foster geoeducation (Tilden, 1957; Macadam, 2018).

In education, especially within formal (educational institutions) and informal (geoparks, museums, websites, nature trails, etc.) environments, digital tools have fundamentally transformed access to and interaction with geoheritage. Online tools such as websites, virtual tours, virtual laboratories, virtual galleries, interactive maps, posts on social media, online games, and many others can represent great mediums for both formal and informal education. However, it is important to realize that interpretation tools are not interpretation itself. As interpretation is communication, it needs to be established methodologically where the geotourism principles are considered and the level of comprehension is well examined by numerous evaluations.

Choosing the right tool for interpretation can foster enjoyment that plays a significant role in whether the user (student, tourist, etc.) will pay attention to given information and interact with it. While the right interpretation behaves like communication it can foster understanding, shape peoples' opinions and attitudes, and initiate education. Combining various online tools with a strong emphasis on their interpretation aspect can enhance the efficiency of geoheritage interpretation and provide both students and the public materials to gain knowledge from based on the chosen language.

This paper presents an opportunity of combining online tools into one learning platform for university students of geotourism through an ongoing research-development initiative at the Faculty of Mining, Ecology, Process Control and Geotechnologies (FBERG) at the Technical University of Košice (Early Stage Grant TUKE 09I03-03-V05-00015). The project aims to design and implement an online digital platform capable of enhancing geoheritage interpretation through virtual means. Although the platform is still under development, the rationale, structure, and projected outcomes provide a comprehensive model for future applications in both formal curricula and informal learning environments.

Methods

This paper is anchored in a dual methodology: a literature-based theoretical synthesis of digital online tools, geointerpretation, pedagogy and geotourism practices, and a description of the project's developmental trajectory.

The project seeks to combine several online tools such as 360° rotational visualizations, audio annotations or storytelling, interactive map system, responsive design and hypertextual elements to create efficient interpretations of geological heritage in context of geotourism as part of the formal university-level education in geotourism. The project is divided into several developmental stages or phases, as shown in Fig. 1 the current phase is planning, where the high-resolution photos for 360° visualizations are being taken, field studies are being conducted, information is being gathered, textual and audio recordings are being produced, etc. All the phases can provide a brief insight into the project development and its methods. A great emphasis is on evaluation, which is part of the process in both planning (front-end evaluation) and implementation (formative evaluation) as well as finalization and post-project phase (summative evaluation). Evaluation tools for collecting qualitative and quantitative data include surveys, interviews, focus group discussions, and observations.
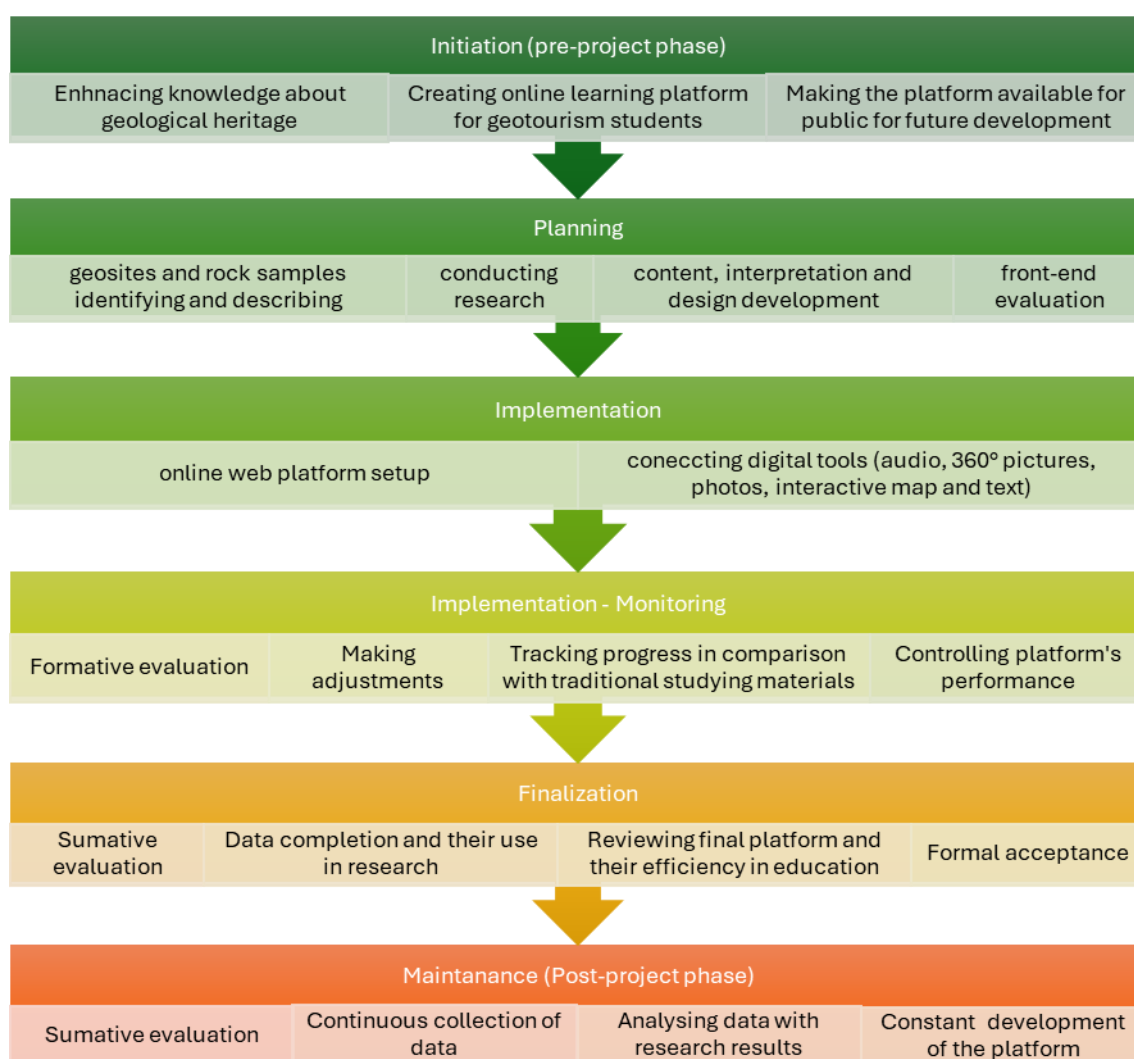
Initiation (pre-project phase)		
Enhnacing knowledge about geological heritage	Creating online learning platform for geotourism students	Making the platform available for public for future development

Planning			
geosites and rock samples identifying and describing	conducting research	content, interpretation and design development	front-end evaluation

Implementation	
online web platform setup	coneccting digital tools (audio, 360° pictures, photos, interactive map and text)

Implementation - Monitoring			
Formative evaluation	Making adjustments	Tracking progress in comparison with traditional studying materials	Controlling platform's performance

Finalization			
Sumative evaluation	Data completion and their use in research	Reviewing final platform and their efficiency in education	Formal acceptance

Maintanance (Post-project phase)			
Sumative evaluation	Continuous collection of data	Analysing data with research results	Constant development of the platform

Fig. 1: Project phases

Results

Interpretation of geoheritage addresses both cognitive and affective domains, striving to democratize access to scientific content and cultivate environmental appreciation (Macadam, 2018; Farsani et al., 2018). The act of interpreting geological heritage transforms complex geoscientific phenomena into narratives that are intellectually comprehensible and emotionally engaging. Ren et al. (2013) frame interpretation as a communication system consisting of a sender (e.g., an institution), medium (e.g., digital platform), and receiver (e.g., learner, tourist). Effective interpretation requires adaptation to

varied learning styles and literacy levels. Digital interpretation tools create opportunities for deeper engagement and various adaptations based on the target users. These include virtual field trips (Eurogeologists, 2020), interactive 3D microscopy (UK Virtual Microscope, 2023), interactive maps (Bailey et al., 2007), virtual reality (Rácz & Zilizi, 2019), mobile apps (Tormey, 2019), interactive websites (Martínez-Martín et al., 2023), and other gamified experiences. Their deployment allows for multisensory interaction, greater accessibility, and pedagogical flexibility. As supported by Fajriasanti & Karyawan (2021), digital tools provide continuity in education, especially in contexts where fieldwork is constrained. In higher education, such tools empower students to explore geoscientific content autonomously and collaboratively. Informally, these tools enrich the interpretive infrastructure of geoparks, museums, and tourism organizations thereby broadening public access to geological narratives (Farsani et al., 2018).

There were several digital tools chosen for this project to establish online learning platform namely 360° rotational visualizations of 36 rock samples, interpretive graphic illustrations of geoheritage and its origin, text and audio comments on individual rocks samples and geosites, hypertext links to the university digital collection of minerals, and an interactive map linking rocks with the geosites where they are located. This learning platform represents an innovative approach to information about rocks as well as geotourism sites where they can be observed regarding their scientific, educational, visual and touristic significance. Even though the platform is aimed at university students of geotourism and thus in formal education the project itself aims to achieve goals also in informal education as well as in research area by going beyond the platform establishment. There are several primary objectives that could be mentioned that the project is striving:

a) in formal education
- teaching geotourism in more engaging and interactive way,
- covering the lack of time and exposure to rock samples students have in real time,
- covering the lack of field trips students have,
- making the connections between tourism, geoheritage, geology and other attributes of the region easier to understand,

b) in informal education
- creating an online free study resource for anyone to use,
- establishing the cornerstone of geo-interpretation for the future development in geotourism,

c) in science by conducting research
- collecting data from users (mainly students) and lecturers as well as online statistics about the platform's efficiency in education,
- analyzing the platform with the current teaching method,
- creating a methodological basis for assessing digital interpretation,
- developing a model for online geo-interpretation aimed at public in geotourism.

Therefore, establishing the online learning platform for teaching geotourism encompasses various expected outcomes as can be seen in Fig. 2.
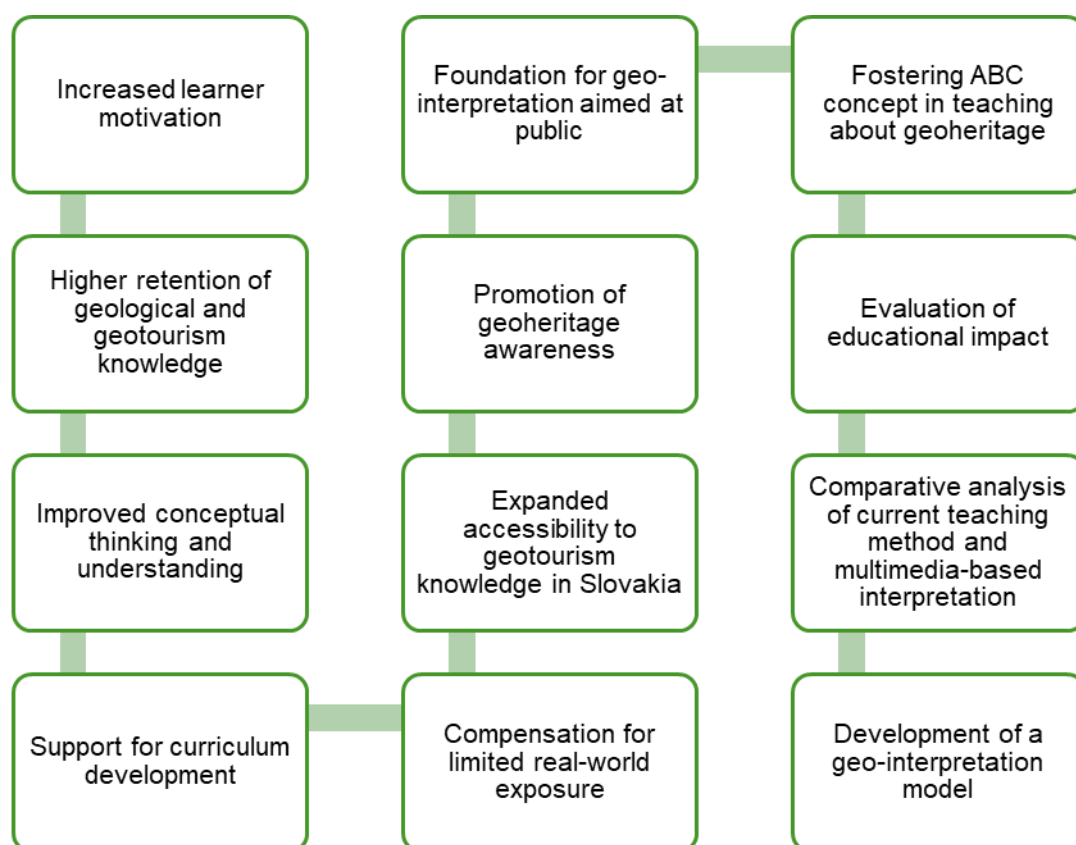
Fig. 2: Expected outcomes of the project of an online learning platform for teaching geotourism

Discussion

The project exemplifies the theoretical-practical alignment necessary in contemporary geoeducation innovation. Drawing on the interpretive principles of relevance, revelation, provocation, and coherence (Tilden, 1957), the project operationalizes these concepts within a digital framework tailored to the needs of primarily academic yet also public users. Research has consistently shown that digital tools contribute to improved learner engagement, inclusivity, and cognitive outcomes (Tormey, 2019; Fajriasanti & Karyawan, 2021). The design of the online learning platform builds upon this literature by embedding interactivity, comprehensiveness, clarity, engagement, scientific accuracy, conceptuality, and adaptive features that cater to diverse learning preferences.

Importantly, the platform reflects the ABC model of geo-interpretation (abiotic-biotic-cultural connections), enhancing the multidimensional understanding of geoheritage sites (Pásková et al., 2021). By embedding cultural, environmental, and scientific narratives into digital experiences, the platform fosters holistic approach in geotourism education and encourages integrative thinking.

Furthermore, its position in structured academic environments as well as in public availability advances the platform to cooperate with Slovak geoparks by complexly interpreting their geological heritage online thus bringing benefits both to students and geoparks. Considering that the project's digital interpretation is aligned with essential geotourism principles as well as general UNESCO geopark frameworks its potential for development in this matter makes even more sense.

Conclusion

The connection of digital technologies and geoheritage interpretation marks a transformative moment in geotourism education. The project serves as a case study for how theoretical insights, technological advancements, and pedagogical imperatives can coalesce into a coherent educational tool. Though currently under development, the platform lays the foundation for innovation in both formal and informal education as well as in research areas. This can lead to a more significant impact on discourse about geotourism, awareness about geoheritage, general interest in this matter, and enhancements in research.

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Souhrn

Článek zkoumá, jak mohou online nástroje zlepšit interpretaci geoheritage ve formálním i neformálním vzdělávacím prostředí. Představuje projekt Technické univerzity v Košicích zaměřený na vývoj digitální vzdělávací platformy, která obsahuje 360° vizualizace hornin, interaktivní mapy a audiovizuální vzdělávací prvky. Cílem těchto nástrojů je zpřístupnit geovědní znalosti studentům a široké veřejnosti, učinit je poutavějšími a pedagogicky účinnějšími. Platforma rovněž podporuje výzkum shromažďováním údajů o interakci uživatelů a výsledcích vzdělávání. Celkově tato iniciativa propojuje vědecký obsah s interaktivními technologiemi s cílem podpořit geoturistiku a geoedukaci.

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