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AI-Enabled Reform of Field-Based Teaching for Geological Disaster Prevention and Mitigation under the OBE Framework

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Abstract

Geological disaster prevention and mitigation is a fundamental task for safeguarding human lives and property. With the rapid expansion of the socio-economic system, anthropogenic impacts on the geosphere have intensified, leading to increased occurrence frequency and hazard intensity of geological disasters. Traditional geological disaster prevention methods primarily rely on manual surveys and empirical judgments, resulting in issues such as low efficiency, high costs, and poor accuracy. Meanwhile, the current field-based course on "Geological disaster prevention and mitigation " exhibits a lack of curriculum diversification, pedagogical obsolescence, and a deficiency in students' practical competence. To address these issues, this study proposes a restructured curriculum framework guided by Outcome-Based Education (OBE) and empowered by artificial intelligence (AI). In recent years, the rapid advancement of artificial intelligence (AI) technology has provided new approaches and tools for geological disaster prevention and mitigation. This study aims to explore how AI technology can be integrated into the field practice course on " Geological Disaster Prevention and Mitigation." Through innovations in teaching content and practical instruction, it seeks to enhance practical skills and scientific literacy.

Keywords

Geological disaster prevention and mitigation; Artificial Intelligence (AI); Outcome-Based Education (OBE); Field-based practice curriculum; Curriculum innovation

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1. Introduction

Geological disaster prevention and mitigation represent one of the key applied fields of Earth sciences and serve as a crucial measure for safeguarding human lives and property. They also constitute an integral component of the national strategy for "Holistic security and comprehensive emergency response." Geohazards are among the most pressing global challenges, and their frequent occurrence poses significant threats to human life, property, and the natural environment. Strengthening geological disaster prevention and mitigation efforts is therefore essential for ensuring national security and protecting public safety[1].

Traditional approaches to geological disaster prevention and mitigation have primarily relied on empirical knowledge and conventional technical measures. However, with the exponential growth of data and the rapid advancement of information technologies, the integration of artificial intelligence (AI) into geohazard management has attracted increasing attention. By leveraging big data analytics, machine learning, and deep learning techniques, AI can significantly improve the accuracy of disaster prediction, optimize response strategies, and ultimately mitigate the losses caused by geohazards[2].

With the growing national emphasis on geological disaster prevention and mitigation, the cultivation of skilled professionals in this field has become increasingly critical[3]. However, the traditional field-based course on "Geological Disaster Prevention and Mitigation" faces several challenges, including a lack of curriculum diversification, outdated pedagogical approaches, and insufficient opportunities for students to develop practical competence. Therefore, integrating artificial intelligence (AI) technologies into this field practice course and carrying out instructional reform and innovation not only fosters innovative thinking and hands-on abilities but also carries substantial practical significance and theoretical value for advancing geohazard education.

2. Analysis of the current status of the "Geological Disaster Prevention and Mitigation" field practice course

2.1. Single and limited teaching content

Traditional field practice courses on "Geological Disaster Prevention and Mitigation" mainly focus on the identification and monitoring of geological hazards, with insufficient emphasis on fostering students' innovation and hands-on abilities. In addition, the teaching content is often limited to common geological hazard types such as landslides and debris flows, while more complex hazards, such as earthquake-related disasters, lack in-depth practical teaching and research.

2.2. Outdated teaching methods

Traditional "Geological Disaster Prevention and Mitigation" field practice courses are typically delivered through teacher-centered lectures with students merely observing, which results in a lack of interactivity and hands-on engagement. Moreover, due to the complexity and hazards of geological disaster prevention work, students often have limited opportunities for direct participation and practice, leading to suboptimal teaching outcomes[4].

2.3. Insufficient student practical skills

Due to limitations in teaching content and methods, practical skills are often inadequate. When confronted with real-world geological hazards, students often lack the problem-solving skills and innovative thinking required. Therefore, it is necessary to reform and innovate the field practice course on "Geological Disaster Prevention and Mitigation" to enhance practical abilities and innovative capabilities[5].

3. Application of Artificial Intelligence in Geological Disaster Prevention and Mitigation

3.1. Data processing and analysis

With the advancement of remote sensing and geographic information technologies, geological hazard data continue to expand. AI technologies can efficiently process and analyze this data, extracting valuable information. For instance, machine learning algorithms can classify and cluster historical disaster records to identify patterns and trends[6]. Fan Xuanmei, in the Youth Scientist Forum, presented a case study on using AI for geological disaster data processing, demonstrating how data analysis can improve the accuracy and timeliness of disaster early warning systems[7]. Specifically, machine learning algorithms can extract key features from large datasets and build predictive models, enabling early warning of potential disaster risks.

3.2. Disaster prediction and early warning

AI technology has demonstrated outstanding performance in disaster prediction and early warning. By developing predictive models trained on historical data, AI can identify potential geological hazards in advance[8]. For example, deep learning-based models can integrate multiple data sources, such as meteorological data, topographical data, and geological data, to conduct comprehensive analyses and predict the probability and impact scope of disasters. Professor Zhou Limin's study proposed that AI-based disaster management should encompass six core dimensions: platform, tools, geography, simulation, decision-making, and society, underscoring the importance of human-machine collaboration in complex and dynamic disaster scenarios[9]. These models enable real-time monitoring and timely alerts, providing a scientific foundation for disaster preparedness and response.

3.3. Disaster identification and assessment

AI technologies are also widely applied in disaster identification and assessment. Using image recognition and natural language processing, AI can rapidly analyze visual and textual information from disaster sites to evaluate the severity of events. For instance, high-resolution drone imagery combined with deep learning algorithms can automatically detect hazards such as landslides, debris flows, and collapses, providing timely information to support disaster relief efforts[10]. Fan Xuanmei's research demonstrated that integrating remote sensing imagery with human cognitive modeling significantly improves the accuracy and efficiency of disaster identification[7]. These applications not only accelerate the recognition process but also substantially reduce the error rate associated with manual assessments.

4. Reform and innovation of the Geological Disaster Prevention and Mitigation Field practice course based on the OBE concept

4.1 OBE educational concept

Outcomes-based education (OBE) is a student-centered, learning-outcome-oriented educational philosophy [11] (**Figure 1**). OBE emphasizes that teaching design should focus on the ultimate learning outcomes students are expected to achieve, highlighting process management and continuous improvement. This approach requires instructors to clearly define course objectives, design well-structured teaching activities, and assess students' learning outcomes through effective evaluation methods[12]. The core idea of OBE is to ensure that every student acquires the essential knowledge and skills necessary to perform competently in real-world tasks[13]. In the "Geological Disaster Prevention" field practice course, the OBE philosophy serves as a guiding framework to define course objectives aimed at developing practical abilities in disaster identification, monitoring, assessment, and mitigation, thereby preparing them to address complex

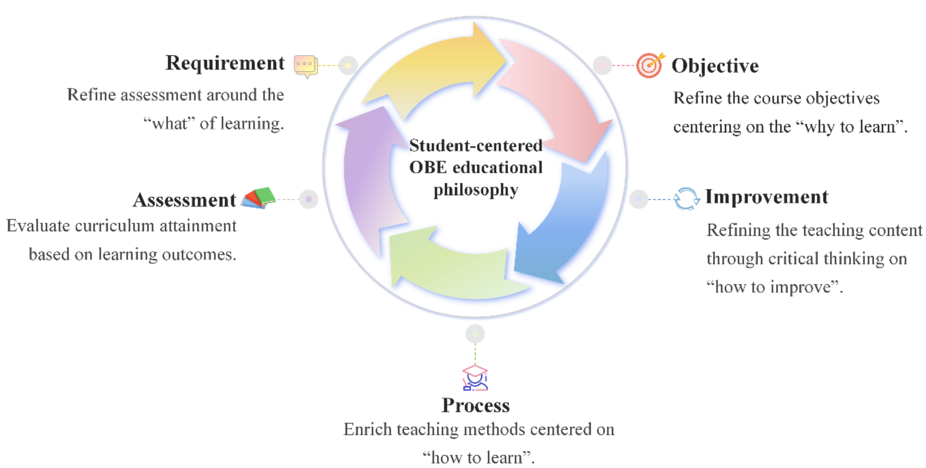

Figure 1. Implementation framework of the OBE educational concept.

engineering geological challenges in future disaster prevention work[14].

4.2. Innovation in teaching content

4.2.1. Integrating typical geological and seismic disaster cases into teaching content

In the "Geological Disaster Prevention" field practice course, representative cases of various geological and seismic disasters should be incorporated into the curriculum. By introducing the types, causes, impacts, and mitigation measures of geological disasters, students can gain a comprehensive understanding of the fundamental theories and practical skills of disaster prevention[15]. At the same time, knowledge related to earthquake monitoring, early warning, risk assessment, and emergency response should be included, enabling students to develop stronger competencies in earthquake disaster prevention and mitigation[16].

4.2.2. Integrating AI applications in Geological Disaster Prevention and Mitigation

The "Geological Disaster Prevention" field practice course should fully incorporate applications of AI technologies in this field. By introducing case studies and underlying principles of AI in disaster monitoring, early warning, risk assessment, and emergency response, students can gain a deeper understanding of the critical role and future potential of AI in geological disaster prevention and mitigation[17]. Furthermore, students should be guided to explore how AI can be applied in real-world disaster prevention practices, thereby fostering innovative thinking and enhancing their practical problem-solving skills.

4.3. Innovation in teaching methods

4.3.1. Integrating AI into VR and AR to enhance field teaching

In the "Geological Disaster Prevention" field practice course, VR and AR technologies can be employed to simulate geological disaster scenarios and support field-based teaching. This approach maximizes student safety during practical training while enriching the overall learning experience. Immersive VR and AR environments allow students to observe the occurrence of geological disasters and the implementation of mitigation measures as if they were on-site, thereby improving interactivity and experiential engagement. Furthermore, incorporating AI for intelligent analysis and optimization of VR or AR scenarios can further enhance instructional effectiveness and create a more dynamic learning environment[18].

4.3.2. Selection and optimization of field routes

In the Geological Disaster Prevention field practice course, field routes should be carefully selected and optimized. Representative geological disaster sites should be chosen for field investigation and observation based on the types and spatial distribution of hazards. At the same time, factors such as actual conditions, weather, and specific teaching objectives should be considered to adjust and refine the routes. This ensures that students gain a comprehensive understanding of the fundamental theories and practical skills required for geological disaster prevention.

4.3.3. Introducing AI-based intelligent evaluation and grading systems

In the Geological Disaster Prevention field practice course, AI-powered evaluation and grading systems can be introduced. By automatically assessing students' notebooks, mapping results, and practical reports, such systems can provide an objective reflection of learning outcomes and practical skills. In addition, AI can be used to analyze learning processes and deliver real-time feedback, enabling them to identify and correct problems promptly, thereby improving both learning effectiveness and overall instructional quality.

5. Challenges and countermeasures

5.1. Technological challenges

(1) Data Quality and Model Accuracy

The construction of virtual field environments and route optimization models relies heavily on large volumes of high-quality data. However, field data are often subject to measurement errors and incompleteness. To address this, it is essential to establish rigorous data quality control protocols and continuously refine AI algorithms to enhance model accuracy and reliability[19].

(2) Enhancement of Intelligent Evaluation Systems

Current AI-driven evaluation systems may struggle to accurately interpret descriptions of complex geological phenomena or assess innovative practices. Continuous improvements in natural language processing and image recognition algorithms are required, supported by domain expert input, to progressively optimize evaluation rules and models for more precise and fair assessment.

5.2. Faculty competence challenges

Faculty members are expected to master emerging technologies such as AI, VR, and AR, along with the corresponding pedagogical approaches. However, some instructors may face difficulties with technology adoption and practical application. To address this issue, universities should strengthen faculty development programs by offering targeted technical training and organizing teaching workshops. Encouraging instructors to actively engage in hands-on practice and innovation can enhance both their pedagogical skills and technological proficiency.

5.3. Cost challenges

Integrating AI, VR, and AR technologies into the curriculum requires significant investment in both hardware and software, including high-performance computing equipment, VR headsets, and specialized software platforms. In addition, there are ongoing costs for system upgrades and technical maintenance. To mitigate these challenges, institutions and relevant departments should actively seek governmental and societal funding support, strategically allocate financial resources, and gradually improve the construction of teaching infrastructure[20].

6. Conclusion

This study explores the application and innovation of artificial intelligence technologies in the field-based course "Geological Disaster Prevention and Mitigation." By examining the limitations of traditional teaching approaches and the advantages of AI integration, it proposes a series of instructional reforms, including innovations in course content and teaching methodologies.

Artificial intelligence not only enhances the efficiency of data collection and processing but also plays a crucial role in risk assessment, early warning, and emergency response. Its integration into the "Geological Disaster Prevention" and " Mitigation field course can significantly improve both instructional efficiency and hands-on capabilities, while simultaneously strengthening their safety awareness and innovative thinking. By combining AI with VR or AR-assisted teaching, optimizing field routes, and implementing intelligent assessment of fieldwork outcomes, the course can better align with national strategic needs and embody the OBE educational philosophy. This approach ultimately elevates teaching quality and cultivates highly skilled professionals in the field of geological disaster prevention and mitigation.

Despite the challenges related to technology, faculty competence, and implementation costs, these issues can be progressively addressed through well-designed strategies, driving the Geological Disaster Prevention and Mitigation field course toward greater intelligence and efficiency. Such efforts will contribute to safeguarding national geological security and protecting lives and property. Looking ahead, as AI technology continues to advance, its applications in geological disaster prevention will become even more extensive. This calls for deeper interdisciplinary integration and sustained innovation to accelerate the development of next-generation techniques for disaster prevention and mitigation.

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Disclosure statement

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