

Opportunities and challenges in big-data-driven environmental science and engineering teaching

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Abstract: With the rapid development of information technologies such as cloud computing and petabyte-level storage, big data is impacting social development and people's daily lives in an unprecedented manner. As a sunrise discipline, environmental science and engineering is confronted with how to respond to the opportunities and challenges brought by the big-data era, which constitutes an important subject for front-line university teachers. This paper introduces the concept and basic characteristics of big data, and discusses its penetrating effects on the teaching of environmental science and engineering: improving the forward-looking nature of teaching content, promoting the transformation of teaching modes, and developing an accurate and precise personalized teaching system.

Keywords: Big Data, Environmental Science and Engineering Major, Teaching Innovation and Reform

1. Introduction

With the rapid development of information technology and the wide application of cloud computing and petabyte-scale data storage, the tide of the Big Data era is exerting a revolutionary influence on social development and people's quality of life. Meanwhile, environmental pollution has become increasingly severe. The differentiation, complexity and diversification of pollution causes have increased the difficulty of pollution control. Environmental protection and governance have become major national strategic demands. Environmental Science and Engineering involves a broader range of disciplines and technologies, and new technologies and theories in collaboration with other disciplines have achieved rapid development. As big data permeates all walks of life, how Environmental Science and Engineering, a sunrise discipline, responds to the opportunities and challenges brought by the big-data era has become an important research topic for front-line university teachers. This paper introduces the concept and basic characteristics of big data and explores its penetrating effects on the teaching of Environmental Science and Engineering.

2. Opportunities for Env. Sci. & Eng. teaching in big-data era

2.1. Connotation, characteristics and global development trends of big data

The ternary world of human, machine and physical objects is moving toward high-level integration, which triggers explosive growth in data scale and high complexity of data patterns, marking that the world has entered the network-enabled big-data era. Generally speaking, big data refers to datasets whose scale is so large that traditional database software tools are incapable of collecting, storing, managing and analyzing [1]. Big data is neither a simple description of data volume, nor the development of specific algorithms, professional technologies or business models. Instead, it represents the sum of major transformations covering data volume, data forms, data analysis and processing methods, as well as concepts and patterns [2].

Big data mainly has four basic characteristics [3]: Large data volume, which is the fundamental attribute of big data; Diverse data types. Various and changeable data types constitute an important feature of big data; Fast data processing speed. The requirement for rapid data processing is one of the key features distinguishing big data from traditional massive-data processing; Low data value density, a vital attribute of

the unstructured data concerned in big-data research. Given its distinct characteristics compared with traditional data, the application and development of big data have attracted great attention from the industry, scientific community and government departments [4]. For instance, the Obama administration launched the Big Data Research and Development Initiative in March 2012, another major scientific and technological deployment following the announcement of the United States' Information Superhighway Initiative in 1993. China held the 424th Xiangshan Science Conference in May 2012, which was China's first major scientific conference themed on big data. Regarded as "the new oil of the future", big-data research has been elevated to national strategic will, which will surely exert far-reaching influences on future scientific-technological and economic development.

2.2. Big-data-era higher-ed reform of environmental science-engineering

The advent of the big-data era will exert a revolutionary impact on the whole society. As an important component of the social subsystem, education is bound to be affected. As the leader of education, higher education is also profoundly influenced by the application of big data. As one of the most dynamic disciplines in the 21st century, Environmental Science and Engineering has encountered both opportunities and challenges of the big-data era amid its rapid development.

3. Challenges to Env. Sci. & Eng. teaching in big-data era

Environmental Science and Engineering integrates scientific knowledge and technologies from diverse fields including chemistry, physics, biology, medicine, geoscience, engineering, economics and law, forming a huge scientific system evolving from multidisciplinary to interdisciplinary research. In recent years, environmental pollution has become increasingly severe. The differentiation, complexity and diversification of pollution-causing factors have increased the difficulty of pollution remediation. Environmental Science and Engineering involves an even broader scope of disciplines and technologies, and relies more heavily on the rapid advancement of new technologies and theories from other disciplines in the integration of science and technology. Big-data technologies mainly include massively parallel processing databases, data mining grids, distributed file systems, distributed databases, cloud computing, the Internet and scalable storage systems. Such technologies will bring new development trends to the Environmental Science and Engineering major.

3.1. Improve the forward-looking nature of teaching content

With social progress and the rapid development of science and technology, it is widely recognized that traditional higher-education teaching content can no longer meet the requirements for cultivating college students' innovative spirit and practical competence, which is specifically reflected in the contradiction between the slow update of textbook content and the rapid development of disciplines. Frontier knowledge of Environmental Science and Engineering refers to the latest research achievements, ongoing research projects and future development trends of the discipline. Timely delivering cutting-edge knowledge and technologies of environmental science to students and cultivating their ability to acquire new knowledge and technologies beyond textbooks constitutes one of the vital approaches to fostering high-quality environmental-protection talents with innovative capabilities. The arrival of the big-data era injects new vitality into such teaching activities. An important feature of big data is that high-quality data resources can be "extracted" from massive and complex information according to specific application demands, and predictive contents can be summarized. In the teaching of Environmental Science and Engineering, while consolidating students' theoretical and experimental operational foundations and integrating scientific-technological frontier knowledge into courses, big-data technologies can be adopted to continuously summarize frontier information and knowledge resources from environmental data sources (such as internationally renowned academic journals including Environmental Science & Technology and official websites such as the United States Environmental Protection Agency[5]). These resources can be converted into teachable language. By virtue of digital teaching resources to optimize curriculum setup, the course content can be made more forward-looking. Students' awareness of tracking disciplinary frontiers and their initiative to acquire new knowledge can be cultivated, which provides a new path for ultimately cultivating environmental-protection talents with innovative thinking and capabilities (Figure 1).

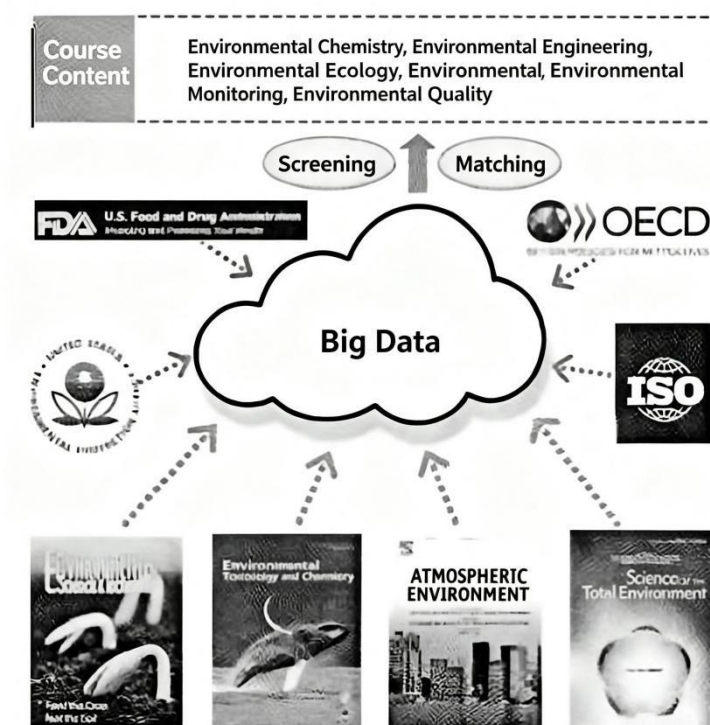


Figure 1 Application of big data

3.2. Promote the transformation of teaching modes

3.2.1. Big-data-driven teaching resource transformation

Against the backdrop of globalized world politics and economy, higher education is inevitably influenced and impacted by globalization. The centralized and isolated university education will be broken with the advent of the Internet-information era. The construction of network-based, digital teaching resource databases in the big-data era endows teachers' teaching modes and patterns with three-dimensional and diversified features. As a mainstream technology for extracting big-data resources, cloud computing is exerting direct impacts on traditional teaching modes and students' learning styles. Cloud-computing networks can not only build interactive and targeted teaching-learning platforms, but also embed digital systems to deploy teaching content on Internet platforms for resource sharing. With the advancement of multimedia technologies, new multimedia services have sprung up and gained popularity on the Internet. Cloud-media platforms feature integrated texts, images, audios and videos, vivid visualization and repeatable playback. Students can access abundant and effective teaching resources anytime and anywhere, which stimulates their emotions, attention and interest from multiple perspectives and greatly improves the effectiveness of experimental teaching.

3.2.2. Cloud-media-supported practical teaching innovation

In practical teaching, various teaching-assistant activities such as courseware sharing, online Q&A, microblog-based teaching evaluation and Fetion-assisted communication can be carried out, which also greatly benefits core teaching activities. It is conceivable that once Environmental Science and Engineering courses are migrated to cloud-media platforms, technology-enabled teaching can realize cross-regional and cross-temporal interactions among teachers, among students, between teachers and students, and even among universities, research institutes and enterprises. Particularly for professional experiments of Environmental Science and Engineering (e.g., environmental chemistry experiments, environmental monitoring experiments, environmental information-technology experiments) and practical sessions (e.g., indoor and field internships, production practice), multimedia virtual simulation laboratories can be constructed on cloud-media platforms to realize three-dimensional teaching modes. Modern intelligent

cloud technologies can also reproduce and analyze pollution processes that cannot be achieved in theoretical instruction, indoor experiments and field observations. This enables students to form intuitive perceptions of pollution-incident processes, facilitates their comprehension of basic concepts and mastery of fundamental principles, and cultivates their capabilities to analyze and solve environmental-pollution problems.

3.3. Develop a refined and accurate personalized teaching system

3.3.1. Logic of big-data-enabled personalized education

Future education advocates precise and accurate personalized education, so big data serves as a vital approach to promoting and realizing educational personalization. Benefiting from its broad data sources, big data enables the formulation of personalized teaching content and the establishment of flexible learning modes based on the analysis of individual students' aspirations and performances. In the big-data era, the educational mode for the Environmental Science and Engineering major should also be "student-oriented". Targeting talent cultivation adapted to social development, universities shall adjust the emphasis of professional basic courses, specialized courses and practical sessions. This contributes to students' personalized development and satisfies diverse students' demands for professional knowledge at different levels.

3.3.2. Construction of personalized talent-training system

From the perspective of talent structure, the demand structure for environmental-related talents in universities can be divided into four categories: academic talents (fundamental-research-oriented and science-oriented), representing top-level talents; engineering talents (application-research-oriented, personalized-training-mode and teaching-system technical-theory-research-oriented) and technical talents (practical-oriented and technology-application-oriented), belonging to the intermediate level; and skilled talents, accounting for the majority. In terms of graduates' career paths, students of this major tend to engage in basic scientific research, environmental engineering, environmental monitoring, environmental planning, environmental management, environmental law enforcement, environmental audit, environmental education and other fields. In the curriculum design of university environmental-related majors, it is necessary to adopt big-data technologies (analytical technologies, storage databases, distributed computing technologies, etc.) to build a relatively accurate personalized talent-training system in accordance with individual students' development orientations (Figure 2). For example, for research-oriented talents who attach importance to students' theoretical knowledge reserve, courses focusing on theoretical improvement can be highlighted, delivered by research-teaching-oriented teachers with solid professional expertise. For application-oriented talents focusing on students' practical competence, practical and design-oriented courses can be prioritized, with experts or engineers with rich engineering practical experience serving as part-time instructors.

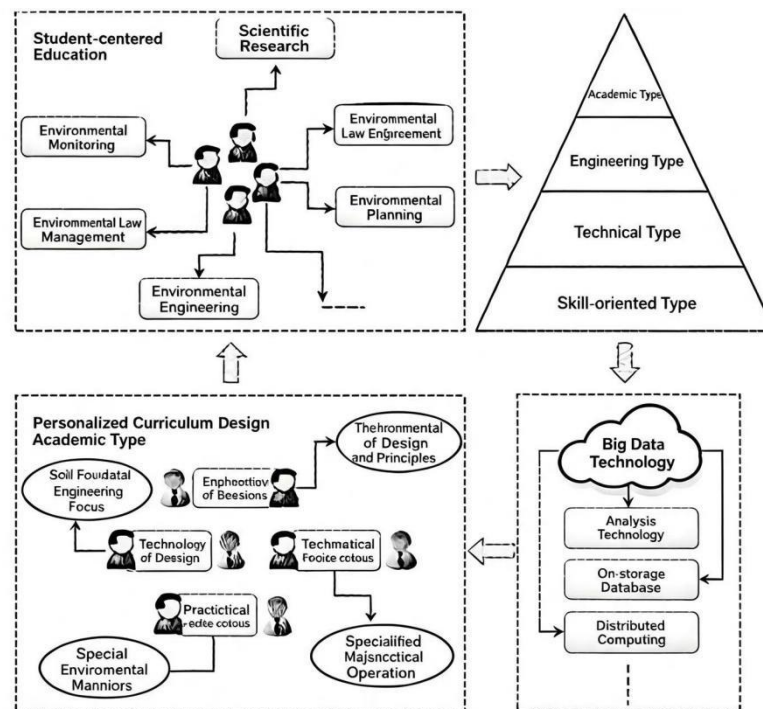


Figure 2 Environmental-related talents in universities in the big-data era

4. Conclusion

The big-data era brings both opportunities and challenges to Environmental Science and Engineering. Meanwhile, the development of big data provides a favorable opportunity for establishing a training mode for compound and innovative talents in this major. With the integration of big-data technologies, the discipline of Environmental Science and Engineering should combine its own developmental characteristics and pursue a development path that conforms to educational laws, scientific teaching modes and personalized talent-training requirements. As front-line teachers of Environmental Science and Engineering, educators should seize unprecedented development opportunities, equip themselves with information-based tools, make full use of big-data resources and analytical technologies to foster innovative teaching concepts, improve information-based teaching capabilities, and transform teaching modes with big data. In addition, the application of big-data technologies in Environmental Science and Engineering requires strong support from professional data-analysis institutions as well as close collaboration among governments, research institutes and educational authorities.

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