



Exploration on the Reform of the Course Construction of “Fundamentals of Cloud and Precipitation Physics and Lightning Science”

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Abstract

This article aims to address the problems encountered in the teaching of the course “Fundamentals of Cloud and Precipitation Physics and Lightning Science” by improving and optimizing classroom content, teaching methods, experimental methods, and assessment methods. The goal is to enrich teaching content, enhance teaching effectiveness, stimulate students’ interest, and cultivate comprehensive talents for the field of atmospheric science through curriculum reform (especially including knowledge graph).

Subject Areas

Atmospheric Science, Course Construction

Keywords

Physics of Cloud and Precipitation, Lightning, Knowledge Graph

1. Introduction

The course “Fundamentals of Cloud and Precipitation Physics and Lightning Science” includes both cloud precipitation physics and lightning science. Among them, cloud precipitation physics, also known as cloud microphysics, is one of the more important branches of atmospheric science. It studies the formation, development, and dissipation processes of clouds, fog, and precipitation, as well as radiation transmission in clouds, cloud optoelectronic phenomena, and cloud precipitation chemistry, etc. [1]. As the most important branch of atmospheric science, cloud precipitation physics is based on atmospheric thermodynamics and dynamics, and is closely related to other research fields in atmospheric science

such as atmospheric physics, meteorology, atmospheric sounding, atmospheric chemistry, and applied technologies. The lightning science section includes fair-weather atmospheric electric field, atmospheric conductivity, space charge and atmospheric currents, charge generation and discharge mechanisms in thunderstorm clouds, and artificial lightning triggering and lightning protection technologies [2]. Due to its comprehensive theoretical knowledge and special position in the professional field, it also puts forward high requirements for teachers' professionalism and teaching ability. However, from the current teaching situation of courses in major universities, there is still a lot of room for improvement in teaching effectiveness. Therefore, strengthening the research on teaching reform of the course "Fundamentals of Cloud and Precipitation Physics and Lightning Science" and promoting continuous improvement and optimization of teaching have become issues that need to be highly valued in this professional field.

2. Overview of the Course "Fundamentals of Cloud and Precipitation Physics and Lightning Science"

The course "Fundamentals of Cloud and Precipitation Physics and Lightning Science" is an important course in atmospheric science, applied meteorology and other majors in domestic meteorological universities. It is a fundamental course under the framework of atmospheric physics curriculum design. The course can be divided into two parts: macroscopic cloud physics and microscopic cloud physics. Macroscopic cloud physics emphasizes atmospheric dynamics issues, while microscopic cloud physics emphasizes phase transition thermodynamics and aerosol mechanics related issues [3]. The educational core of this course lies in the use of macroscopic and microscopic observations and detections, combined with physical and chemical experiments, physical and chemical simulations, and numerical simulations, to artificially influence cloud precipitation operations, laying an important theoretical and scientific foundation for students to enter relevant departments such as meteorological bureaus in the future. Therefore, this course lays an important foundation in atmospheric science, especially in atmospheric physics, and has a significant impact on human survival and development [4].

The content of the course "Fundamentals of Cloud and Precipitation Physics and Lightning Science" possesses significant specialization. Firstly, its disciplinary development has a profound historical background and encompasses extensive subject matter. The research objects cover scales ranging from the microscale, storm scale, mesoscale, and the synoptic scale. Secondly, studying cloud precipitation physics requires a theoretical foundation from other branches of atmospheric physics, including atmospheric thermodynamics, atmospheric dynamics, atmospheric radiation, atmospheric acoustics, optics, and electromagnetics, and upper atmospheric physics. Simultaneously, knowledge of synoptic meteorology and climatology is also essential. Consequently, students must possess a solid comprehensive foundation. It is evident, therefore, that this course presents a considerable learning challenge. To ensure students truly master the course knowledge

and can apply it to practical situations, it is imperative to employ scientific teaching methodologies and engaging experimental projects.

3. Innovative Teaching Reform Methods for the Course of “Fundamentals of Cloud and Precipitation Physics and Lightning Science”

1) Enriching classroom teaching content

The so-called enrichment of classroom teaching content does not mean that more classroom content is better. We should build a scientific teaching system based on the learning situation of our school students and the special requirements of talent cultivation [5]. The true meaning of “enrichment” is to enhance the fun of classroom content, highlight the key points of the classroom on the premise of solid basic knowledge, combine theoretical knowledge with practice through images, and guide students to learn independently and absorb and digest knowledge.

2) Optimizing classroom teaching methods

The course of “Fundamentals of Cloud and Precipitation Physics and Lightning Science” involves a wide range of topics and complex professional knowledge. Optimizing teaching methods refers to the need to combine sensory and rational understanding in the teaching process to explore the scientific significance of atmospheric physics. Firstly, for abstract fields, especially those involving professional terminology, dynamic legend demonstrations should be used in teaching to increase the proportion of multimedia teaching methods and vividly visualize abstract knowledge [6]. Secondly, to comprehend and master knowledge, it is necessary to trace its roots, which requires higher professional guidance from teachers. Thirdly, inspire students on how to break through barriers and apply the content of the course “Fundamentals of Cloud and Precipitation Physics and Lightning Science” to cultivate students into applied professionals in fields such as weather forecasting and artificial weather modification.

3) Innovating experimental teaching methods

In the past, in long-term experimental teaching, teachers have been trapped in relying mainly on teachers telling students about the process of listening to experiments. In the process oriented experimental learning approach [7], students gain scientific knowledge and master experimental methods, but often overlook the cultivation of students’ observational and innovative thinking due to the help of teachers. Therefore, teachers should improve and innovate the experimental teaching mode, abandon the experimental teaching of “blindly demonstrating the operation process”, but this does not mean that teachers should give up the way of demonstrating the operation process. Instead, they need to change their teaching ideas from the traditional positive experimental teaching design concept to the “reverse design” experimental teaching design concept guided by cultivating students’ thinking and exploration consciousness. Fundamentally, they need to transform their experimental teaching ideas, achieve student-centered status, and

think from the perspective of students to guide the design of experimental teaching [8]. Moreover, to integrate teaching experimental resources, teachers should collect high-quality courses in colleges and universities to share network resources, learn and update experimental teaching methods, and take their essence.

Knowledge graph is an important technology in artificial intelligence. It employs AI technology and natural language processing algorithms, promoting the deep integration of artificial intelligence technology with education and teaching [9]. There are two fundamental methods for constructing a knowledge graph. The first is to extract relationships between relevant knowledge points from massive data and literature using methods such as machine learning. The second is to establish, modify, and refine the knowledge graph based on the existing experience of expert teachers. The data sources for this course primarily include relevant textbooks, literature, and open courseware from various universities. These data resources are then systematically visualized using artificial intelligence, that is, constructing the knowledge graph. It provides a technical route and strategy for realizing the digitization construction and practice of courses. Knowledge graph is rich in information such as entities, concepts, attributes, relationships, etc., making machine understanding and interpretation possible, and providing technology and methods for realizing the digitization construction and practice of courses [10]. The knowledge graph of the course “Fundamentals of Cloud and Precipitation Physics and Lightning Science” is a structured, visual, and adjustable knowledge system that abstracts the course content as “points” and links them together through “lines” to form a relational network. Knowledge graph can provide students with a structured learning platform from another perspective, enabling the association and fusion of fragmented educational data, showcasing the logical relationships of knowledge, and recommending the optimal learning path. The core of knowledge graph is knowledge “association”, which creates value and activates the value of data (i.e. teaching resources). In the flipped classroom teaching mode, students can independently learn relevant knowledge points through knowledge graphs before class. Existing data [11] indicates that over half of the surveyed graduate students in atmospheric science believe that the flipped classroom is feasible in teaching. Furthermore, this flipped classroom teaching model demonstrates significant advantages in meteorology education [12]. The learning resources and path planning functions provided by knowledge graphs can help students efficiently preview course content and engage in in-depth discussions and interactions with teachers and other classmates in the classroom. This model not only improves students’ self-learning ability, but also enhances classroom interaction and participation [13].

4) Improving the methods of assessment and management

Assessment is one of the necessary links in teaching activities, which is a necessary means to evaluate students’ systematic mastery of knowledge and test teaching effectiveness. Previously, our school’s current assessment method for the course “Fundamentals of Cloud and Precipitation Physics and Lightning Science”

was a closed book exam, with mid-term and final exam scores accounting for 70%. Some students were more likely to memorize before the exam, blindly pursuing the so-called high scores of exam-oriented education, and unable to combine theory with practice. Therefore, considering multiple levels and aspects, it is particularly important to improve the assessment management methods. Firstly, reducing the proportion of final closed book exam scores, preferably with a process-based assessment as the main theme, implementing diversified assessment methods, and forming an assessment framework composed of attendance rate, classroom performance, experimental situation, interactive performance, and final exam multiple elements, emphasizing the cultivation of students' comprehensive application ability. Secondly, strengthening the utilization of knowledge graphs, shifts the focus from memorization-based question types in assessment content to emphasizing the understanding and application of knowledge, and forms an open-ended assessment. For example, teachers can provide a core knowledge point, and students can use programming software to conduct theoretical analysis and write paper abstracts based on theoretical knowledge. In the process of writing the paper, the focus is on examining students' innovative, logical, and meticulous thinking. Thirdly, guiding students to self-evaluation or peer-evaluation, so that each student can constantly reflect, summarize, and optimize their learning methods through mutual evaluation.

4. Conclusion

As an important theoretical course in atmospheric science, "Fundamentals of Cloud and Precipitation Physics and Lighting Science" plays an irreplaceable role in improving students' scientific literacy, enhancing their innovation ability, and laying the foundation for subsequent courses. Teachers focus on students, continuously improve teaching concepts, and are committed to stimulating students' intrinsic potential and learning motivation, promoting the construction of online and offline courses, as well as blended first-class courses in university physics. Therefore, the reform of the course system construction of "Fundamentals of Cloud and Precipitation Physics and Lightning Science", especially the use of knowledge graphs, helps students to more efficiently access accurate information and master the subject content accurately, making efforts and contributions to cultivating innovative talents with both moral integrity and talent for the future.

Conflicts of Interest

The authors declare no conflicts of interest.

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