Theoretical Framework and Practical Paths for the Teaching Reform of Meteorology in Ethnic Universities: A Case Study of Sichuan Minzu College

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Abstract In the teaching of natural science courses in ethnic universities, the traditional model faces common problems such as abstract content, single teaching methods, and disconnection from local needs. In this paper, for the Meteorology and Climatology course of Sichuan Minzu College, a three-in-one reform framework of "hybrid teaching - project-based learning - culturally responsive teaching" was constructed. This framework emphasizes student-centeredness, competency-based orientation, and cultural awareness-led guidance. It integrates traditional ecological knowledge into the curriculum system, and forms a systematic teaching reform plan by reconfiguring teaching content, innovating teaching methods, and reforming assessment mechanisms. The aim is to provide theoretical support and practical paths for the teaching reform of meteorology and related natural science courses in ethnic universities.

Key words Ethnic universities; Teaching reform; Culturally responsive teaching; Project-based learning; Meteorology

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In the context of intensified global climate change and frequent occurrence of extreme weather events, the significance of meteorological science has become increasingly prominent. Meteorology, as a fundamental discipline studying atmospheric phenomena and their evolution patterns, serves as a crucial technological support for disaster prevention and mitigation, ecological civilization construction, and food security. Within the higher education system, enhancing meteorology education and cultivating talents with a solid theoretical foundation, strong practical abilities, and a high sense of social responsibility hold profound strategic significance.

In ethnic minority areas, the teaching of natural science courses such as meteorology in universities faces unique challenges and opportunities. Many ethnic regions are located in fragile ecological areas and sensitive climate zones, such as the Qinghai - Tibet Plateau and its surrounding areas. Offering high-quality meteorology education is of more urgent practical needs for serving local sustainable development and enhancing regional climate adaptability. However, the traditional teaching model that mainly involves one-way knowledge transmission often fails to effectively stimulate the learning interest of students from diverse cultural backgrounds. Moreover, it may even lead to "culture shock" due to its deviation from their life experiences, thereby affecting teaching effectiveness and the quality of talent cultivation.

Sichuan Minzu College is located in Kangding City, Garzi Tibetan Autonomous Prefecture, Sichuan Province. As the only ethnic undergraduate university in Sichuan, it serves multiple ethnic-inhabited regions including Tibetan, Qiang and Yi areas. Its talent training goal is to cultivate applied talents to serve the local economic and social development. In December 2025, Garzê Meteorological Bureau and Sichuan Minzu College signed a cooperation agreement and established long-term cooperative relationships in areas such as joint talent cultivation, shared practice bases, and collaborative scientific research, which provides an important practical basis for the reform of the Meteorology and Climatology course. Based on the above background, taking the Meteorology and Climatology course of Sichuan Minzu College as a case, teaching reform paths specific for ethnic universities were explored to improve course quality and meet the needs of regional talent cultivation.

1 Theoretical framework: "three-in-one" teaching reform model

The teaching reform framework constructed in this paper is centered on the organic integration of three theories: blended teaching, project-based learning, and culturally responsive teaching, forming a systematic "three-in-one" teaching model.

1.1 Blended teaching: reconfiguration of teaching process

Blended teaching refers to an innovative model that combines traditional face-to-face teaching with online learning. Its core concept is to optimize the teaching process through information technology, break the limitations of time and space, and achieve personalized learning centered on learning. The constructivist learning theory emphasizes that students are the active constructors of knowledge. Blended teaching supports students in conducting au-

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tonomous exploration and knowledge construction before class by providing abundant online resources and interactive tools. In the meteorology course, blended teaching has been proven to effectively resolve the contradictions of limited class time, rich content, and high difficulty. Research shows that after blended teaching is adopted, students' learning interest, autonomous learning ability, and course grades are significantly better than those in traditional teaching classes[1-2]. In this reform framework, blended teaching assumes the function of a technical support platform: before class, micro-lessons, preview materials, and quizzes are pushed through the online platform; during class, high-level cognitive activities such as case analysis, group discussions, and experimental operations are focused on; after class, students submit their results and organize asynchronous discussions through the platform.

1.2 Project-based learning: core teaching method Project-based learning (PBL) is a student-centered teaching approach that enables students to conduct continuous exploration around a complex and realistic problem or challenge, ultimately producing public works or solutions. PBL emphasizes "learning by doing" and aims to cultivate critical thinking, problem-solving skills, collaboration abilities, and creativity. Meteorology is closely linked to the real world and is suitable for the implementation of PBL. Existing research has combined PBL with discussion-based teaching and applied it to the Atmospheric Remote Sensing Technology course[3]. Another scholar guided students to analyze the triggering conditions of extreme weather events through the long-term analysis of cases in the Meteorology and Climatology course, effectively enhancing students' data analysis skills and scientific inquiry literacy[4]. In this reform framework, PBL, as the core teaching method, guides the semester's learning with driving questions, and enabling students to achieve knowledge construction and ability enhancement through the completion of specific project tasks.

1.3 Culturally responsive teaching: core concept guidance Culturally responsive teaching (CRT) was proposed by scholars such as Geneva Gay. Its core proposition is that education should respect and make good use of students' diverse cultural backgrounds, experiences, and knowledge frameworks, and transform them into bridges for effective teaching rather than obstacles to be overcome. CRT aims to create inclusive classrooms and enhance the relevance and effectiveness of learning by connecting course content with students' cultural experiences. Integrating traditional ecological knowledge (TEK) into science education has multiple values. TEK refers to the knowledge, practices, and belief systems accumulated and passed down over generations by indigenous or local communities in their long-term interaction with the environment. In the field of meteorology, TEK is manifested in local weather proverbs such as "reading clouds to predict the weather", the twenty-four solar terms, phenology-based climate judgments, as well as traditional agricultural production models adapted to specific climatic conditions. Previous studies have confirmed that combining the meteorological proverbs of ethnic groups such as Tibetan and Yi ethnic group with modern meteorological data can verify their scientific core[5-6]. In the reform framework, culturally responsive teaching constitutes core concept guidance, provides a value orientation for the selection of course content and the design of teaching activities, and ensures that the reform truly responds to the cognitive characteristics and cultural needs of students in ethnic universities.

1.4 Three-in-one internal logic The theoretical innovation of the reform framework lies in integrating the above three theories deeply. The blended teaching, as the technical platform and process framework, provides support for the implementation of PBL and CRT. Project-based learning, as the core teaching activity, transforms abstract knowledge into meaningful inquiry tasks. Cultural responsive teaching, as the soul and content source of the project, ensures that the project theme is closely related to students' cultural background and local reality. The three support each other to form a systematic and multi-dimensional teaching system, which is particularly in line with the educational goals and student characteristics of ethnic universities.

2 Reform paths: taking Sichuan Minzu College as an example

2.1 Reconstruction of curriculum content Based on core theoretical knowledge such as atmospheric composition, radiation balance, atmospheric circulation, and weather systems, the content of the Meteorology and Climatology course is reconstructed from the following three dimensions.

Firstly, the traditional ecological knowledge of the ethnic groups in the Western Sichuan Plateau is integrated. It is needed to systematically collect meteorological proverbs, seasonal wisdom, production experiences, and meteorological elements in myths and legends of Tibetan, Yi, and Qiang ethnic groups. Some scholars have systematically sorted out the weather forecast contents in Tibetan proverbs[5]. The Yi ethnic area also has a large number of meteorological proverbs based on long-term production practices. This content will serve as the introduction resource and project topic source for the course.

Secondly, regional research findings are incorporated. The Qinghai – Tibet Plateau is the "Asian Water Tower" and a "amplifier" of climate change, and its climate change has a significant impact on the ecosystem of the Western Sichuan Plateau. The course will introduce the latest regional research results of climate change in the Qinghai – Tibet Plateau and the causes and predictions of extreme weather events in the southwest region, enabling students to connect their learned knowledge with local realities.

Thirdly, meteorological data processing skills are expanded. In the experimental and practical sessions, training on open access to meteorological data, processing and analysis, and visualization is added. Students can obtain historical data through platforms such as the China Meteorological Data Network and learn to use tools like Excel and Python for analysis of basic data.

2.2 Implementation of "three-in-one" integrated model At the beginning of the semester, a driving question was released:

"How can we utilize modern meteorological science to interpret and inherit the traditional ecological wisdom of the ethnic areas in western Sichuan to address future climate challenges?". Focusing on this core question, 4 – 5 students in a group select one of the following sub-projects to conduct in-depth research.

Project 1 is the scientific verification and digital inheritance of traditional meteorological proverbs in the Tibetan – Qiang – Yi Ethnic Corridor. Student groups conduct community research, interviews, or literature review to collect at least 15 local meteorological proverbs. They obtained corresponding regional historical meteorological data (temperature, precipitation, wind direction, *etc.*) from the China Meteorological Data Network, and used statistical methods (correlation analysis and probability test) to verify the accuracy of the proverbs. The final output includes a research report containing the data analysis process and conclusions, and a short video or WeChat post introducing the proverb and its scientific principles to achieve digital dissemination.

Project 2 refers to the investigation of campus microclimate and analysis of its correlation with local agricultural and livestock production. Student groups use portable meteorological instruments (thermometers, anemometers, *etc.*) to conduct fixed-point observations on different substrates (lawns, concrete surfaces, beside water bodies, and forest land) within the campus, and continuously record data for more than two weeks. They analyze the influence patterns of different substrates on elements such as daily temperature changes, humidity, and wind speed. Combined with local agricultural and livestock production habits (such as the time for yak grazing, the sowing period of barley, *etc.*), they propose adaptation suggestions based on microclimate characteristics. The output contains a well-illustrated investigation report and a diagram for the distribution of campus microclimate.

Project 3 is analysis of typical meteorological disasters in Garzê Prefecture. Each student group selects a typical meteorological disaster that occurred in Garzê Prefecture in the past ten years (such as heavy snow, drought, mountain flood, and hail), and analyzes the causes, process, losses, and response measures of the disaster through literature search, data collection, and field investigation (if conditions permit). Based on the knowledge learned in the course, the effectiveness and shortcomings of the existing disaster prevention and mitigation system are evaluated, and simple community-level disaster response suggestions are proposed. The output includes a case analysis report, which is presented in the form of PPT or poster in class.

The online platform fully supports the progress of the project. Before class, basic theory micro-lessons, TEK reading materials, and dataset links are pushed out; a pre-class quiz is set to test the pre-class learning effect. During class, project discussion, peer evaluation, case analysis, and experimental operation are conducted, and high-level cognitive activities are carried out. After class, students submit interim results, hold open forums for discussion, and conduct interactive Q&A sessions between teachers and students through platforms.

2.3 Practical teaching reform and diversified assessment In terms of practical teaching, the inquiry-oriented transformation of traditional confirmatory experiments is carried out. For instance, the experiment of "the observation of air temperature and humidity" is transformed into "comparative study on the impact of different underlying surfaces on daily changes in temperature"; the experiment of "precipitation observation" is expanded into a design experiment of "fabrication of a simple rain gauge and its precision calibration". At the same time, by leveraging the practical platforms mentioned in the cooperation agreement and PBL projects, "micro internships" are carried out, the centralized final internship is changed to project-based practices.

In terms of assessment methods, a diversified system that emphasizes both process evaluation and final evaluation is established to completely change the situation of "one exam determines one's entire life". The specific composition of grades is as follows.

Process-based assessment (50%) includes online participation (10%), homework and classroom performance (10%), laboratory reports (10%), mid-term progress report of PBL projects (10%), and teamwork and peer evaluation (10%). Summative assessment (50%) contains final outcomes of PBL projects (research reports/works) (30%), and open-book final exam (focusing on analytical and discussion questions) (20%). This assessment design encourages students to shift their focus from grades to the improvement of abilities and qualities, and comprehensively reflects students' learning commitment and ability growth.

3 Expected outcomes and prospects

3.1 Expected outcomes For students, through multi-sensory and multi-pathway learning, their academic performance is expected to significantly improve; their practical innovation ability, teamwork ability, and problem-solving ability will be systematically exercised; students will develop a dual respect for modern science and traditional wisdom, and their sense of identity with their hometown and their sense of responsibility to serve their hometown will be enhanced.

For teachers, teachers shift from a transmitter of knowledge to a designer, guide, and collaborator of learning. Their proficiency in information technology application and teaching research ability are enhanced, and the practice of teaching reform itself can be transformed into high-level teaching research papers and teaching achievements.

For schools and society, the reforms implemented successfully will have distinct national characteristics and contemporary features. Through the platform of the cooperation, application-oriented talents who are proficient in science and technology and also understand local culture are provided to Garzê Prefecture and the western ethnic areas of Sichuan Province, thereby precisely serving the local development. Meanwhile, the scientific exploration and interpretation of traditional ecological knowledge will contribute to the protection, inheritance and innovation of excellent ethnic cultural traditions.

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3.2 Research limitations and prospects This research is currently at the theoretical conception stage. All design plans and expected outcomes need to be verified through real teaching practice. Subsequent research will proceed along the following directions. Firstly, this plan will be proposed as a school-level or provincial-level educational reform project, and a cross-disciplinary teaching team will be established to conduct pilot teaching in 1 – 2 natural classes. Secondly, mixed research methods such as questionnaire surveys, in-depth interviews, and performance comparisons are used to collect empirical data and test the reform effectiveness. Thirdly, based on the feedback from the pilot, the teaching model will be continuously optimized, and the promotion paths in different majors (such as ecology and agriculture) in ethnic universities will be explored. In the future, the exploration of teaching reform rooted in the cultural soil of ethnic groups and integrating modern educational concepts will surely play a unique and important role in cultivating "reliable, employable, and competent" applied talents in ethnic regions.

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