

Construction and practice of a "1+2+3+4" training system for innovative undergraduate talents in public health and preventive medicine

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Abstract

This study aimed to build and implement a "1+2+3+4" teaching reform model for innovative undergraduate talents in public health and preventive medicine with high quality. After more than 10 years of practice and implementation of the "1+2+3+4" teaching reform program, the teaching reform team trained a large number of innovative undergraduate students in public health and preventive medicine with high quality. The researchers set up a teaching reform team with high titles, high education, young age, and good educational gradient: titles and education. The team guided the undergraduate students in preventive medicine to obtain many firsts in the same grade and major. The team instructed undergraduates to obtain the highest quantity and quality of projects, patents, theses, and awards. The team obtained several provincial teaching platforms. The teachers of the teaching and reform team significantly improved their operation. The "1+2+3+4" teaching reform model has clear training objectives. Based on the present research, the "1+2+3+4" is a set of undergraduate training systems with interactive teaching and research modes, which can not only cultivate innovative undergraduate talents in public health and preventive medicine but also improve the teaching and research ability and level of teachers.

Keywords: Innovative form; preventive medicine; teaching reform; undergraduate.

1. INTRODUCTION

In response to the training objectives and tasks of "Strengthening the organic integration of science and technology innovation and talent training, encouraging university students to engage in scientific research, and cultivating their interest in exploration and scientific spirit through innovative practice" in the National Medium and Long-Term Science and Technology Development Plan (2006–2020) (Chandrasekaran, 2021; Lane et al., 2020), the current research group, at first, sets up a teaching reform team with high titles, high education, young age, and good educational gradient: titles (25% for senior, 37% for associate, and 38% for junior) and education (37% for doctor and 63% for master) (Figure 1 and 2). Next, the researchers designed a teaching reform plan of "1+2+3+4" in 2009 to establish 1 center (improving students' practical innovation ability is the center of undergraduate training), 2 types of practice (providing students with two types of practice platform carriers, namely, on-campus research and innovation practice and off-campus social service practice) (Read, 2016), 3 guarantees (preliminary guarantees: the teaching reform model is to strengthen the practical training program; to guarantee the process: the whole process quality assurance mechanism; and to guarantee the result: high quality and high quantity of output), and 4 types of research results (scientific publication, patent authorization, project funding, and award acquisition)(Figure 3) (Li et al., 2020; Li, Xu, et al., 2020; Chen, 2021; Xie et al., 2023).

Figure 1
Composition ratio of team teachers' education

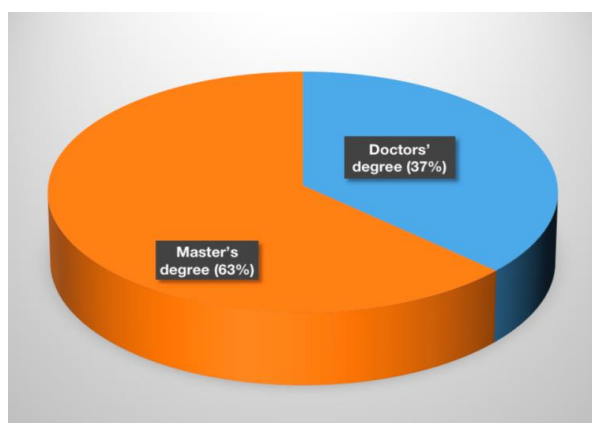
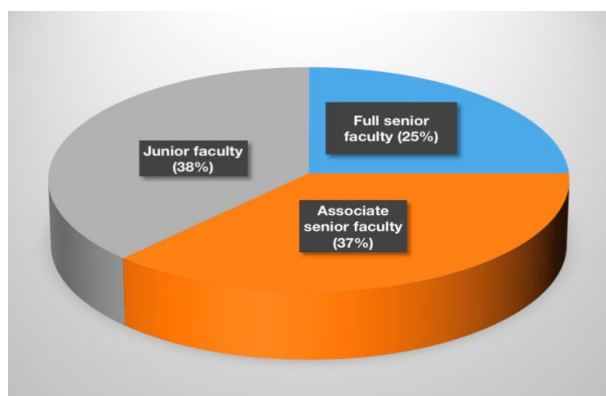


Figure 2
Composition ratio of team teacher support

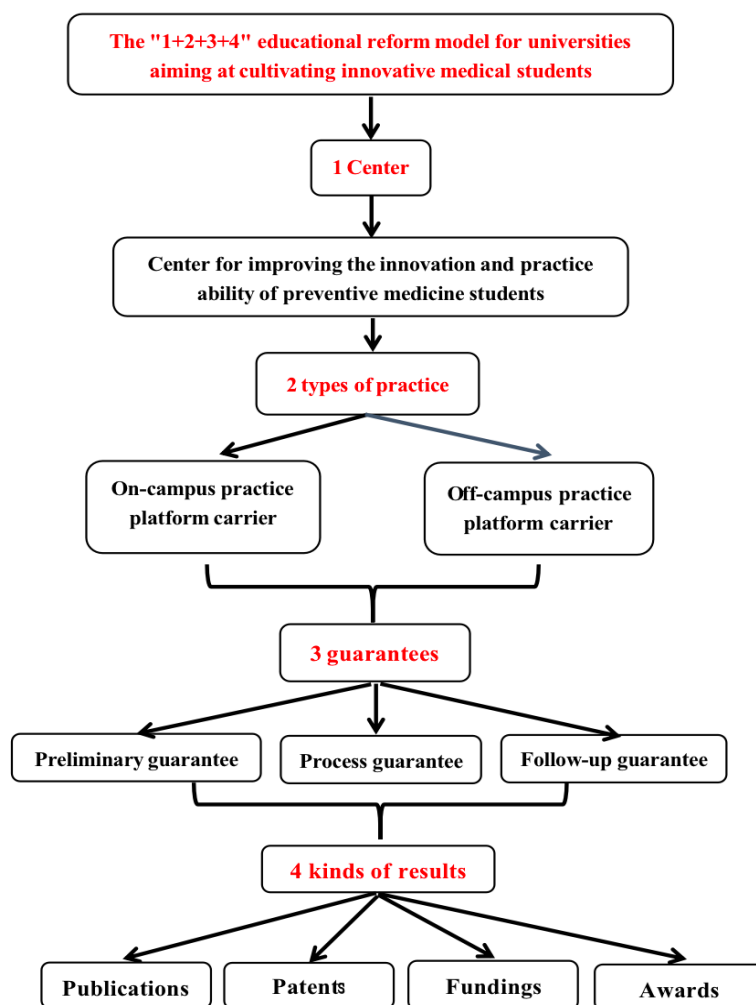


1.1. Purpose of study

The goal was to train innovative undergraduate students in public health and preventive medicine with high quality.

Figure 3

Technical route of "1+2+3+4" teaching reform cultivation model



2. METHOD AND MATERIALS

2.1. Participants

The research involved undergraduate talents in public health and preventive medicine at the School of Public Health, Zunyi Medical University, Zunyi, Guizhou, China, between the years 2009 and 2023.

2.2. Data collection

The research was a longitudinal study, which collected data from observation. First, the researchers set up a teaching reform team with high titles, high education, young age, and good educational gradient: titles (25% for seniors, 37% for associates, and 38% for juniors) and education (37% for doctor and 63% for master). The

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"1+2+3+4" teaching reform model was established: 1 center (improving students' practical and innovative ability is the center of undergraduate training), 2 types of practice (providing students with 2 types of practice platforms and carriers for on-campus research and innovation practice and off-campus social service practice), and 3 guarantees (preliminary guarantees: the teaching reform model to strengthen the practical training program; to guarantee the process: the whole process quality assurance mechanism; and to guarantee the result: high quality and high quantity of output), and 4 kinds of research results (scientific publication, patent authorization, project funding, and award acquisition). After 12 years of practice, the researchers trained innovative preventive medicine undergraduates with high quality. The four kinds of research results were the first among the undergraduate students of the same major.

2.3. Procedure

(1) Change the traditional concept of teaching professional courses and let scientific research enter the classroom

The teachers of this team integrated the divergent thinking and creative thinking of scientific research into the concept of lectures, integrated scientific research projects into classroom teaching, and closely combined scientific research achievements with theoretical teaching (Sarzosa et al., 2020; Svoboda et al., 2021; Huang et al., 2019; Lv et al., 2024). At the same time, the teaching process took the key problems to be solved in the project as a clue, took the theoretical knowledge of the textbook as the background, took the technical operation of the practical teaching as the basis, and built a case teaching mode combining scientific research projects and practical teaching. The case teaching mode not only enriched and expanded the content of theoretical teaching, but also enhanced the application of theory and practice for students so that the students could continuously cultivate practical innovation ability in the process of analyzing and solving problems (Das et al., 2021; Li et al., 2022; Thawesaengskulthai et al., 2024).

(2) Optimize the structure of practical teaching courses and promote the interaction between scientific research projects and practical teaching

The teachers of this team optimized the structure of practical teaching courses and streamlined the verification experimental courses (Thu et al., 2021; Wang, 2017), while appropriately increasing research, design, and open experiments and opening a "second classroom" to strengthen practical teaching. The professional teachers decomposed and condensed the scientific research projects into individual experimental objectives and allowed students to design their own experimental contents and experimental plans according to the experimental objectives to fully exploit the practical ability and innovation potential of college students. The team cultivated students' practical and innovative abilities with innovative practical content, an excellent scientific research platform, and a perfect practical teaching system (Alneyadi et al., 2019).

(3) Establishing a research group of students under the responsibility of high-level professional teachers to involve students in scientific research

The team established an experimental group of college students' innovative projects under the responsibility of professional teachers, who fully guided students' participation from the establishment and development of scientific research to its completion (Hickey et al., 2019). The professional teachers introduced their research direction and fund projects to students in detail and divided the research projects into several subprojects with the teaching contents, and each subproject became a separate topic. The students were allowed to choose their supervisors and subprojects according to their interests (Jones & Lerner 2019). The students of the same subproject formed a research team and, under the guidance of the team teacher,

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reviewed the relevant literature, the design of experimental protocols and technical routes, the conduct of experiments, and the writing of the final report (Grailer et al., 2022). This not only strengthened the teamwork spirit of the students but also stimulated their initiative to participate in scientific research (Chen et al., 2023).

(4) Constructing a practical innovation assessment system to supervise the cultivation of students' practical innovation ability

The team constructed a phased assessment system for practical innovation throughout the 5 years of university. At the end of the first and second years, we evaluated the undergraduate students' mastery of professional theoretical knowledge and their ability to collect data and consult the literature. In the middle of the junior and senior academic years, the research proposal was compiled to examine the students' experimental design, and whether it was feasible, research-oriented, and innovative (Gelula & Yudkowsky 2002). At the end of the fifth year, a summary report of the project was submitted by the research group. According to each student's experimental report, the teacher made a comprehensive evaluation of the students' practical innovation ability by combining their attitude, practical hands-on ability, and the size of their contribution to the innovation point during the experimental process, and the research results were compiled into a paper for submission (Arries et al., 2021).

3. RESULTS

After more than 10 years of practice and implementation of the "1+2+3+4" teaching reform program, the teaching reform team trained a large number of innovative undergraduate students in public health and preventive medicine with high quality, and the results were as follows.

3.1. The teaching reform model focused on the cultivation of students' practical and application abilities, and the "second classroom" was held regularly and quantitatively to strengthen practical teaching

The supervisor led students out of school to put public health education practice on the ground, carry out real-world teaching, and guide students to conduct more than 20 social services activities, such as voluntary medical consultation, drug distribution, and resultant science propaganda, in 10 cities and villages in Guizhou province, including Zunyi City and Xiaoguan Township in Suiyang County, for example, "Epidemiological survey of asthma prevalence and environmental etiology," "Indoor and outdoor soot PM2.5 pollution monitoring and health hazards," "Chronic non-communicable diseases and environmental causative relationship," "Depressed patients nonylphenol exposure site investigation," "Investigation of environmental endocrine disruptors in urban and rural rivers, tap water, vegetables, and fruits," and "Health and poverty alleviation at the grassroots level." The supervisor carried out the second classroom training and led undergraduate students to carry out social services and public lectures on nutrition and health in the community more than 50 times during weekends, which made the number of beneficiaries reach more than 10,000, such as carrying out prevention and voluntary consultation of chronic diseases such as diabetes and fatty liver, carrying out scientific popularization of results such as environmental causative factors of obesity and depression, carrying out investigation and evaluation of children's growth and development, and so forth.

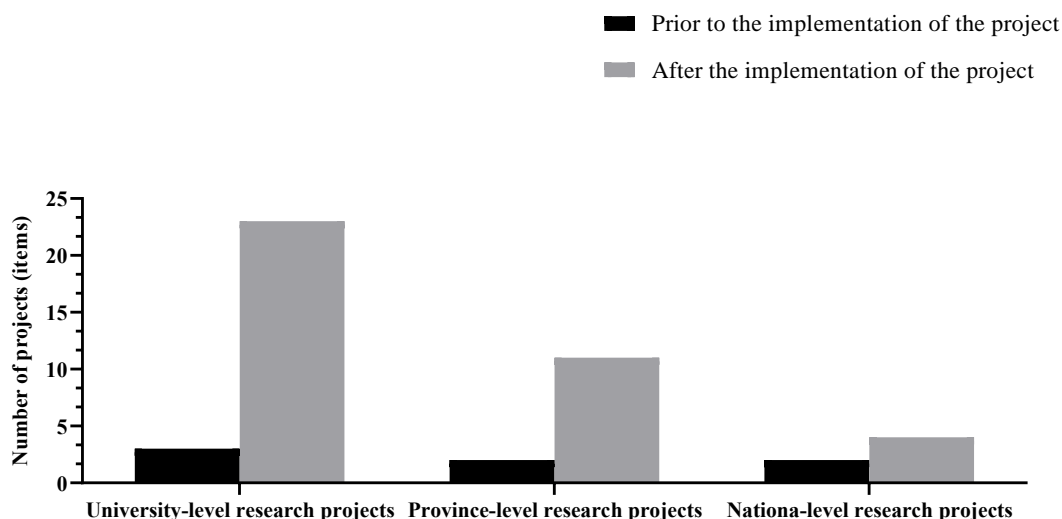
3.2. High-quality training of a large number of innovative preventive medicine undergraduates

Under the high-quality guidance of the team teachers, the output of undergraduates was rich in form and characterized by high quality and large quantity. The undergraduates obtained 34 national, provincial, and university-level undergraduate innovation and entrepreneurship projects, 30 authorized patents, and 62 papers published by undergraduates, including 22 papers in SCI journals, with 303 citations. Moreover, 2

students were awarded excellent graduates of Guizhou province; 64 students were awarded national and university-level scholarships, and 3 were awarded good students; 13 students were awarded university-level excellent thesis for undergraduates; 12 students studied for doctoral or master's degrees. Since the "1+2+3+4" educational reform program began in 2006, the scientific research ability of undergraduate students has been greatly improved. There was a much greater increase in both the number of "Student Innovation Projects" at different levels and several research articles published by undergraduate students at different levels, before the implementation of educational reforms (2006-2015) than after the implementation of educational reforms (2016-2023, Figure 4 and 5). Since 2016, undergraduate students gradually improved the quality of scientific research, which includes the increasing number of articles published by undergraduate students in journals with high ranks in the Science Citation Index (Figure 6), and an increasing proportion of patents applied by undergraduate students from 2016 to 2023 (Figure 7).

Figure 4

Comparison in the number of "Student Innovation Projects" at different levels before and after the implementation of educational reforms.

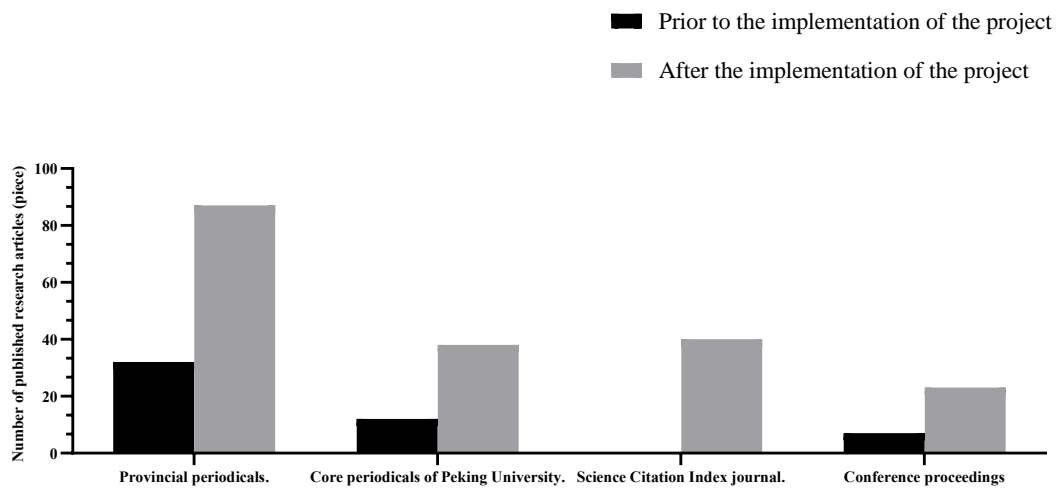


The pre-implementation time of educational reforms is from 2006 to 2015; The post-implementation time of educational reforms is from 2016 to 2023 (figure 4).

Figure 5

Comparison in the number of published articles published by undergraduate students at different ranking levels in the Science Citation Index before and after the implementation of educational reforms.

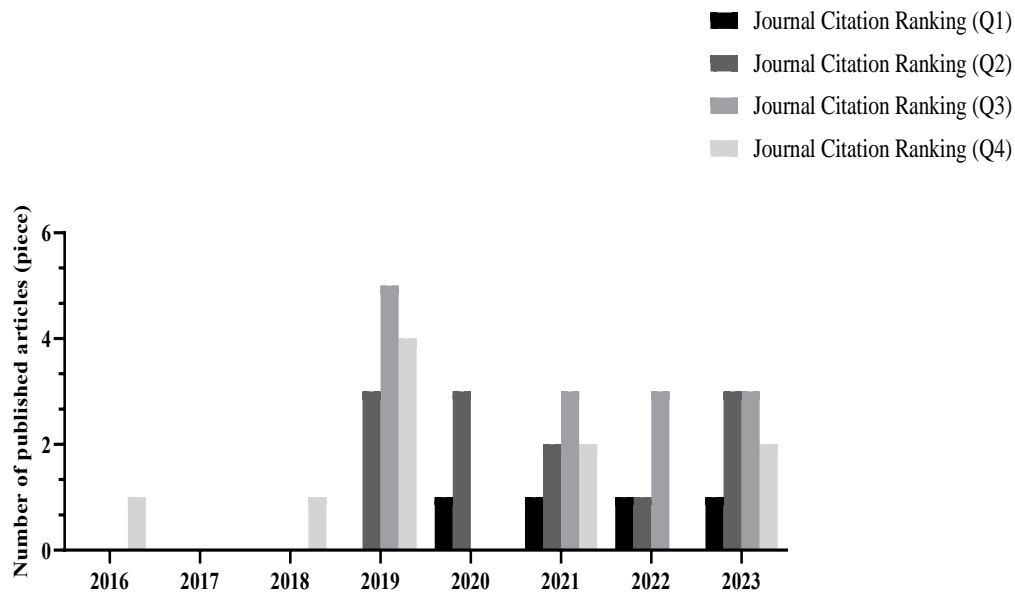
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The pre-implementation time of educational reforms is from 2006 to 2015; The post-implementation time of educational reforms is from 2016 to 2023 (figure 5).

Figure 6

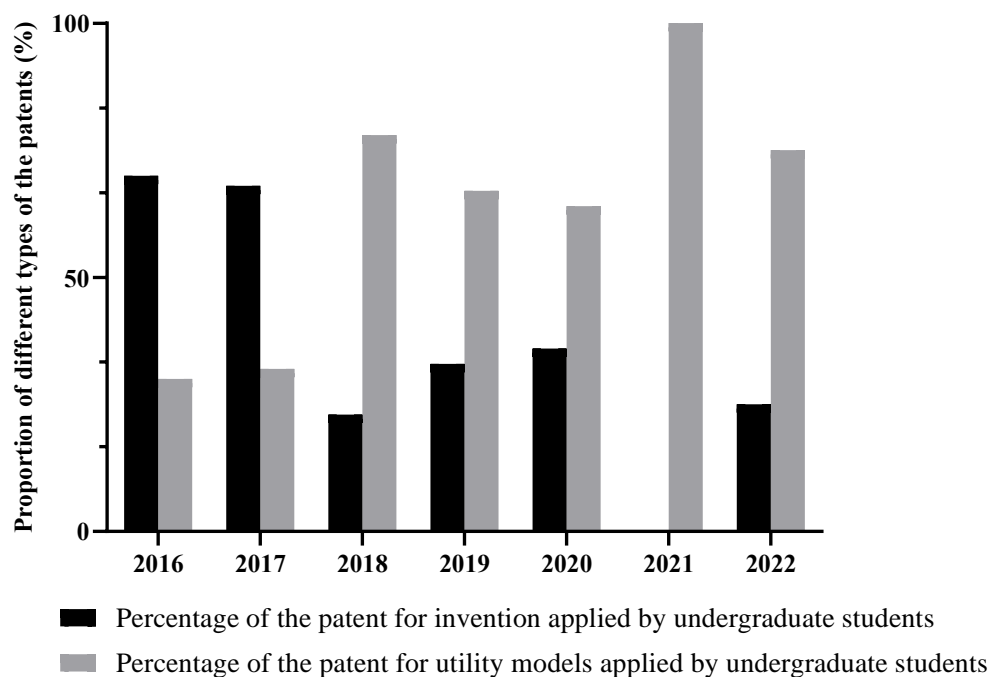
The number of articles published by undergraduate students in Science Citation Index journal with different Journal Citation Reports Ranking from 2016 to 2023.



The pre-implementation time of educational reforms is from 2006 to 2015; The post-implementation time of educational reforms is from 2016 to 2023 (figure 6).

Figure 7

The proportion of different types of patents applied by undergraduate students from 2016 to 2023.



The pre-implementation time of educational reforms is from 2006 to 2015; The post-implementation time of educational reforms is from 2016 to 2023 (figure 7)

3.3. Through the education reform, the faculty was greatly enhanced and won many provincial honors

Among the faculties in the team, two persons were selected as Guizhou provincial experts, two persons enjoyed the special allowance of Guizhou provincial government, one person was selected as Guizhou high-level innovative "ten or hundred level" talent, one person was selected as Guizhou excellent young scientific and technological talents, one person was selected as Guizhou top talents in science and technology in colleges and universities, one person was a part-time doctoral supervisor of Shanghai Jiao Tong University School of Medicine, one person was among the first batch of high-level "thousand level" talents in Guizhou province, and two persons were among the first batch of mentors of university students' innovation and entrepreneurship education in Guizhou province. Among the team, three were selected as university-level excellent teachers, and nine were selected as university-level excellent thesis supervisors for undergraduates. The team won 4 teaching and reform projects and published 29 teaching and reform papers. It also won 5 third prizes in the university-level young teachers' lecture competition and multimedia courseware competition. The team won two third prizes for provincial scientific research achievements, one second prize for scientific research achievements of the Medical Association, and one natural science achievement prize from the Department of Education. In addition, the number of teaching reform papers published by the team members increased (Figure 8). Similarly, the number of teachers who have been promoted to professional titles such as professor or associate professor increased from 2009 to 2023 (Figure 9).

Figure 8

The number of teaching reform articles published by the team members from 2009 to 2023.

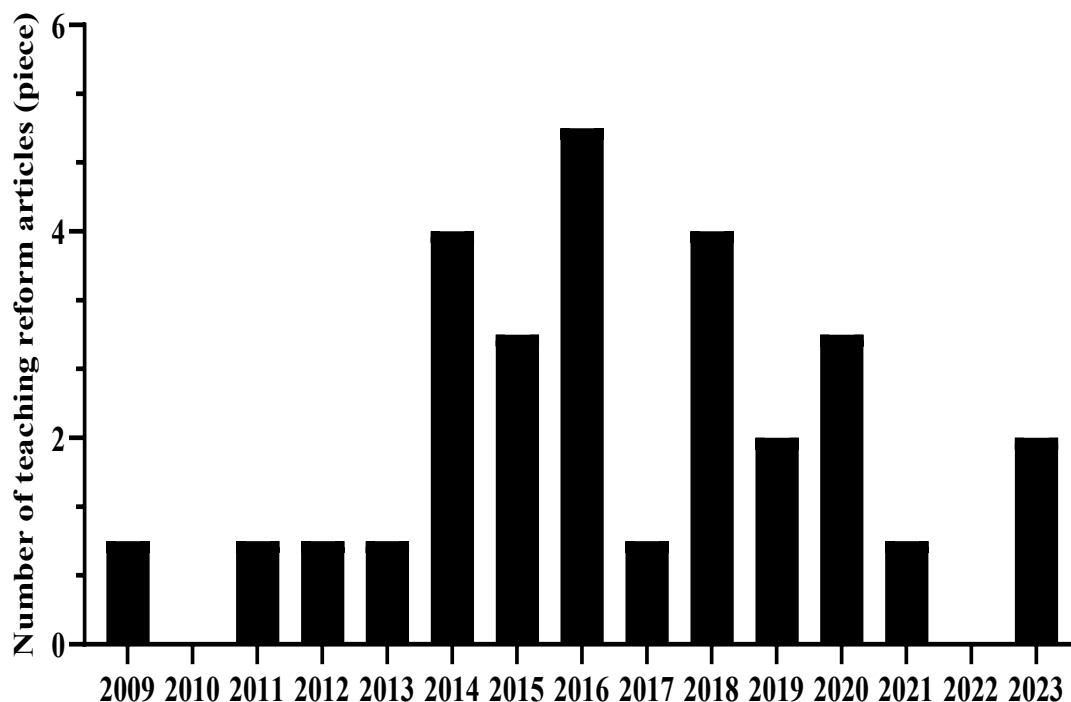
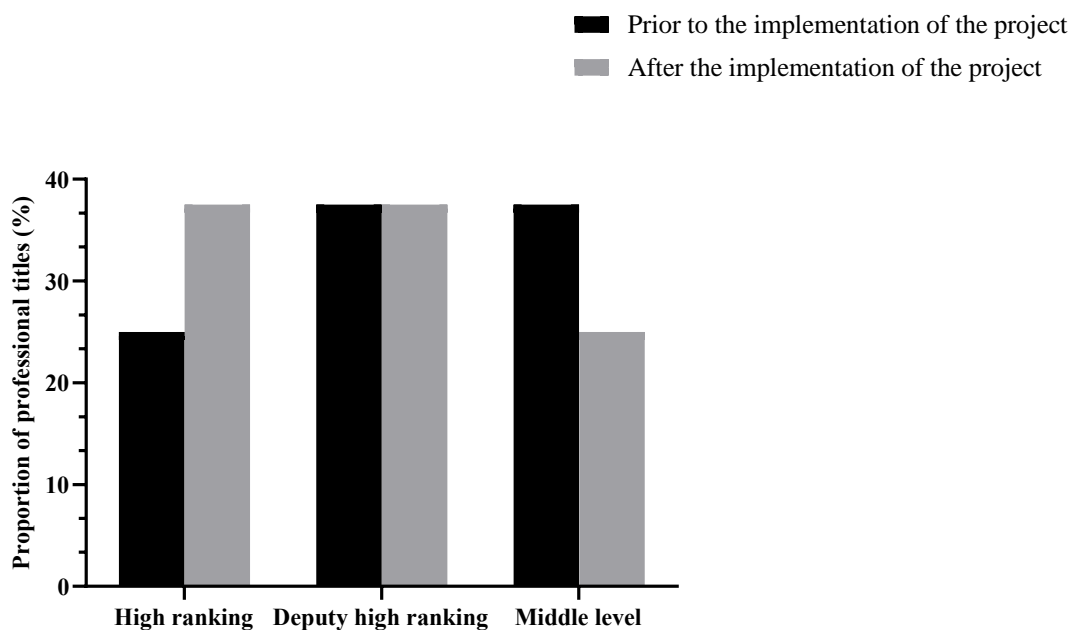


Figure 9

Comparison in the proportion of professional titles among team members before and after the implementation of educational reforms.



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The pre-implementation time of educational reforms is from 2006 to 2015; The post-implementation time of educational reforms is from 2016 to 2023.

4. DISCUSSION

This teaching reform model mainly solved the following teaching problems. First, it changed the traditional concept of teaching professional courses, brought scientific research into the classroom and from the classroom into practice, and cultivated college student's ability for independent exploration and learning (Dong et al., 2021). Second, it optimized the structure of practical teaching courses, optimized the objectives and tasks of teachers in cultivating talents, and promoted interaction between scientific research projects and practical teaching (Qian et al., 2023; Sullivan et al., 2023). Third, the scientific research group of college students under the responsibility of professional teachers was established to improve the practical innovation ability and the quantity and quality of scientific research output of undergraduates and to promote the awareness of scientific and technological innovation and production practice ability of college students (Sui et al., 2022; Collins et al., 2023; Asfahani, 2024; Tagorda-Kama et al., 2023; Gao & Dong 2022).

Finally, after the aforementioned teaching reform practice, the team guided undergraduate students in preventive medicine to obtain a series of achievements after 12 years of teaching reform, such as obtaining the first "Innovative Experimental Program for Undergraduates" in the School of Public Health (Koh et al., 2023; Pham et al., 2023), guiding the first publication of thesis by the undergraduate students as the first author in the School of Public Health in 2011, guiding the undergraduate students to obtain the first national "Grand Invention" project in the School of Public Health in 2012 (Paina & Glenn 2023; Mendonça & Castro 2023), guiding the undergraduate students to obtain the first core journal paper in 2013, and guiding the students to obtain the first authorized patent in the School of Public Health in 2016 (Haythorn, 1923; Parkinson et al., 2023).

In the last 12 years, the team guided undergraduates to obtain 6 national-, 12 provincial-, and 26 university-level innovation and entrepreneurship projects (Baskin & Davis 2023); 30 authorized patents; 239 papers published by undergraduates, including 40 in SCI journals and 50 in Beitu core journals, with 303 citations; and 14 national-, provincial-, and university-level competition awards (Scherr et al., 2023). Among these undergraduate students, 2 were awarded as excellent graduates of Guizhou province; 64 received national- and university-level scholarships and the honor of "Three Good Students"; 13 received university-level excellent theses for undergraduates; and 12 continued to study for master's and doctoral degrees. The team also won 4 university-level teaching and reform projects and published 29 teaching and reform papers, including 2 in core journals; won 5 awards, including the third prize in the university-level young teachers' lecture competition and multimedia courseware competition (Alqahtani et al., 2023; Liu et al., 2020). Three of them were awarded as excellent teachers at the university level, and nine of them were awarded as excellent undergraduate thesis supervisors at the university level (Zeng et al., 2021; Yu et al., 2022). The team instructors led undergraduates to actively open a "second classroom" to strengthen practical teaching and guided students to participate in social services such as chronic disease prevention, medical consultation (Anitha et al., 2022; Kuwahara et al., 2023), popularization of science, and public lectures on nutrition and health for more than 50 times, benefiting more than 10,000 people, which was reported by the provincial media for many times (Landfried et al., 2023).

This educational reform project had three innovations. First, the guiding ideology, training objectives, and tasks were innovative (Meredith et al., 2023). This achievement was based on the guiding ideology, cultivation

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goals, and tasks formulated by the National Medium- and Long-term Scientific and Technological Development Plan (2006–2020), which was advanced in guiding ideology (Krasna & Fried 2021). Second, the content of teaching reform was innovative. This achievement was the first attempt to put forward the "1+2+3+4" teaching reform training model with one center, two types of practice, three guarantees, and four forms of research results in preventive medicine. This model was the first to establish and practice the teaching reform model among undergraduate students of preventive medicine at the university (Nelson-Hurwitz et al., 2021; Sullivan & Galea 2021). After 12 years, it achieved remarkable achievements in cultivating innovative undergraduates with high quality. Third, the teaching results were innovative. The undergraduates trained in this teaching reform model produced large-quantity and high-quality results, whether in terms of publication of articles, projects, patents, and awards, or terms of social service and public welfare practice. They were in the leading position among the preventive medicine undergraduates of the same grade and major (Anderson et al., 2021; Currie et al., 2020).

5. CONCLUSIONS

The team guided the undergraduate students in preventive medicine to obtain many firsts in the same grade and major: the first national and provincial "Student Innovation Project," the first publication in the core journal and Science Citation Index (SCI) journals with the first author, and the first authorized patent with undergraduate students as the first inventor. The team instructed undergraduates to obtain the highest quantity and quality of projects, patents, theses, and awards, including 45 national provincial-level student innovation and entrepreneurship projects with 80 authorized patents; 239 papers published by undergraduates, including 40 in SCI journals and 50 in Beitu core journals; 16 national, provincial, and university-level competition awards at the undergraduate level; 64 national- and university-level scholarships and 3 good students; 14 undergraduates with university-level excellent thesis; and 33 students pursuing the study for masters and doctoral degrees. The team obtained several provincial teaching platforms: the team's course in Preventive Medicine was awarded the first-class course in Guizhou province and the first-class specialty of Preventive Medicine in Guizhou province, and the teaching platform was awarded the Guizhou Province Experimental Teaching Demonstration Center of Preventive Medicine and the Key Discipline of Public Health and Preventive Medicine in Guizhou Province. The teachers of the teaching and reform team significantly improved their operation: they obtained 11 teaching and reform platforms and topics at the university level, published 29 teaching and reform papers (138 citations) and 164 scientific research papers, and received 10 provincial and departmental teaching and research achievement awards.

In summary, the "1+2+3+4" teaching reform model had the characteristics of a clear guiding ideology, clear training objectives, outstanding practical ability, a strong guarantee system, and obvious quality innovation. It was a teaching and scientific research interaction mode of the preventive medicine professional bachelor training system. The educational reform model strengthened the organic combination of science and technology innovation and talent cultivation, encouraged college students to engage in scientific research, and cultivated their interest in exploration and scientific spirit in the innovative practice, which had a high promoting effect.

Ethical Approval: The study adheres to the ethical guidelines for conducting research.

Competing interests: The authors declare that they have no competing interests.

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Author contributions: Jie Yu and Jie Xu designed the study. Yu Yang, Lina Ma, Zhigang Jiang, Dan Jiang, Binli Hu, Ya Luo, Jie Xu, and Jie Yu analyzed and interpreted the data. Yu Yang, Lina Ma, Jie Yu, and Jie Xu conducted the investigation work. Jie Yu wrote the manuscript; Jie Xu revised the manuscript. All authors agree to be accountable for all aspects of work ensuring integrity and accuracy

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