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Research Article

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Analysis of the Present Situation of the Cultivation of Scientific Research and Innovation Ability in Medical Students and Exploration of the Scientific Research Training Mode

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Abstract

Background: *This study aims to investigate, from different perspectives, the problems faced and the countermeasures suggested by five-year clinical medical students in an entrepreneurship training programme for medical students to promote medical teaching reforms.*

Methods: *A total of 600 five-year clinical medicine majors (grades 16-18) at Bengbu Medical College (including those who did and did not participate in large-scale entrepreneurship programmes) were studied by means of internet questionnaires and interviews. Statistical analysis was used to analyse the results of 568 questionnaires.*

Results: *Students generally hope for improvements in the quality and mode of scientific research instruction; they have a strong interest in scientific research and hope to receive training in scientific research in their spare time and that does not interfere with their studies. Moreover, students desire improvements in incentive policies for innovation, the introduction of liberal laboratory opening policies and the optimization of funding for scientific research.*

Conclusions: *Clinical medical students in our hospital attach great importance to the cultivation of scientific research ability. The results clarify the problems faced by medical undergraduates participating in entrepreneurship programmes and provide specific quantitative data for the reform of medical education modes to cultivate the innovation capacity of medical students.*

Keywords: College Student Entrepreneurship Training Programme (Dacheng), Scientific Research and Teaching Mode, Scientific Research Atmosphere, Time Arrangement, Laboratory Opening

Background

Innovation is the soul of a nation's progress. It is the responsibility of those leading scientific research innovation in colleges and universities to improve the quality of students and to cultivate innovative talent through scientific research activities. How to train innovative talent at the undergraduate level of higher medical education has long been a concern of medical educators, but the quality of scientific research training in higher medical education in China has not received due attention. Undergraduates' skill level in scientific research is not high, and their scientific research consciousness is not strong. In 2010, the Medical Department launched an innovative experimental project for medical undergraduates aiming to "promote the cultivation of students' innovative spirit, team consciousness and practical ability and improve students' ability to comprehensively use knowledge and research ability". The goal is to improve the scientific research ability of medical students. On this basis, our school has conducted a number of "great innovation" projects to guide the training of innovative medical talent, but room for improvement remains [1-3]. This paper takes adjusting the mode and method of scientific research training for medical students as the research problem. Furthermore, it takes students as the main population of interest and investigates the problems in and the desired countermeasures for developing skills related to innovation. This paper is expected to provide data for the training of medical students and for reforming the new medical education model through research.

Methods

1. A total of 568 five-year students majoring in clinical medicine (grades 16-18) at Bengbu Medical College participated in this study. According to whether the students participated in a medical student entrepreneurship training programme (large-scale entrepreneurship programme), they were di-

vided into two groups: a large-scale entrepreneurship group and a non-large-scale entrepreneurship group.

2. Research methods: Online questionnaires and interviews were used. The design and administration of the Internet questionnaire and the data collection were performed online, and one anonymous survey could be completed per WeChat account. The questionnaire explores the scientific research teaching mode, time arrangement, scientific research atmosphere, reward mechanisms and experimental conditions from multiple perspectives. The goals of the interviews and research with the students, programme instructors and managers in charge of the programmes were to understand the participants' views and to derive suggestions for undergraduate participation in programmes.
3. Statistical analysis of the results of the questionnaire was performed in Excel. Count data were expressed as the number of cases and percentages, and comparisons between groups were performed by the $\chi 2$ test ($p < 0.05$). All statistical analyses were performed with SPSS 23.0 statistical software. The interview data were analysed by descriptive statistical analysis.

Results

A total of 600 questionnaires were distributed, and 568 valid questionnaires were recovered, for a recovery rate of 94.7%. Among the respondents, 234 (41.2%) were in grade 16, 154 (27.11%) were in grade 17, and 180 (31.69%) were in grade 18. There were 256 males (43.66%) and 194 students (34.15%) who had participated in or were participating in large-scale entrepreneurship programmes.

The Scientific Research Instruction and Teaching Mode Desired by Students

The survey results show that more than 70% of the students in both groups (84.54% of students in the large-scale entrepreneurship group and 86.63% of students in the non-large-scale entrepreneurship group) think that essential courses on scientific research design, experimental records and thesis writing are needed. Furthermore, scientific research courses should focus on experimental technology, research topic selection and design, literature retrieval and reading, data analysis, and paper writing. The results are shown in Table 1.

Table 1: Demand for the Different Types of Scientific Research Courses

Research project	Name	Whether or not a participant took part in a medical student entrepreneurship programme (%)		Total (568)	χ^2	p
		Participant (194)	Non-participant (374)			
Specific type of course you most want to participate in	Literature retrieval and reading	30 (15.46%)	50 (13.37%)	80 (14.08%)	8.251	0.083
	Scientific research topic selection and design	38 (19.59%)	120 (32.09%)	158 (27.82%)		
	Experimental technology	68 (35.05%)	138 (36.90%)	206 (36.27%)		
	Data analysis	36 (18.56%)	40 (10.70%)	76 (13.38%)		
	Thesis writing	22 (11.34%)	26 (6.95%)	48 (8.45%)		

In terms of teaching methods, 47.89% (Participation 46.39%, Non-participation 48.66%) of students prefer practical projects, while 34.51% (Participation 41.24%, Non-participation 31.02%) of students desire teacher-student interaction. Among the students, 66.90% (Participation 68.04%,Non-participation 66.31%) want their mentors to participate in the project in person, and 20.42% (Participation 19.59% and Non-participation 20.86%) want their teachers to guide them at the macro level. In terms of instructor arrangement, nearly half of the students (49.3%, Participation 44.33% and Non-participation 51.87%) would like a "double tutor system" in which, for example, they would receive joint guidance from college and clinical teachers, and many prefer "assistance from members of the research group"; see Table 2 for details.

Table 2: Guidance Methods for Scientific Research Projects

Research project	Name	Whether or not a participant took part in a medical student entrepreneurship programme (%)		Total (568)
		Name	Non-participant (374)	
Teaching methods used in scientific research courses	The teacher lectures in class	18 (9.28%)	50 (13.37%)	68 (11.97%)
	Case discussion between teachers and students	80 (41.24%)	116 (31.02%)	196 (34.51%)
	Teach via a practical project	90 (46.39%)	182 (48.66%)	272 (47.89%)
	Combination of video and face-to-face teaching	2 (1.03%)	18 (4.81%)	20 (3.52%)
	Other: the way of teaching that you think is appropriate	4 (2.06%)	8 (2.14%)	12 (2.11%)
Mode of instructor guidance	Stocking type: all students make their own decisions and teachers provide guidance on the macro level	38 (19.59%)	78 (20.86%)	116 (20.42%)
	Push: the teacher participates in the student project and pays close attention to its progress	132 (68.04%)	248 (66.31%)	380 (66.90%)
	Intermediate type: students do not report, teachers do not care; students must take the initiative	4 (2.06%)	18 (4.81%)	22 (3.87%)
	Designate graduate students to provide guidance	18 (9.28%)	20 (5.35%)	38 (6.69%)
	Other: based on need	2 (1.03%)	10 (2.67%)	12 (2.11%)
Instructor arrangement	A mentor personally instructs	24 (12.37%)	46 (12.30%)	70 (12.32%)
	"Double tutor system", such as the provision of joint guidance by college teachers and clinical teachers	86 (44.33%)	194 (51.87%)	280 (49.30%)
	Tutor assigns graduate students to give guidance	10 (5.15%)	8 (2.14%)	18 (3.17%)
	Tutor and graduate students work together	30 (15.46%)	54 (14.44%)	84 (14.79%)
	The members of the research group participate in helping, "one-on-one" and "pass, help and pick up"	44 (22.68%)	72 (19.25%)	116 (20.42%)

Whether it is case-based teaching combined with PBL teaching or classroom discussion teaching, the two groups of students think that it plays an important role in cultivating interest in scientific research, which can stimulate students' interest and arouse their enthusiasm for learning.

Timing

The results of the survey regarding the time spent on project implementation show that 82.75% of students (92.78% of students in the large-scale entrepreneurship group and 77.54% of students in the non-large-scale entrepreneurship group) believe that conducting scientific research projects has a positive effect and can improve their overall ability. Only 5.28% (0% of students in the large-scale entrepreneurship group and 8.02% of students in the non-large-scale entrepreneurship group) think that scientific research projects consume considerable amounts of time and affect their normal study schedule and life. A significant difference between the two groups is observed ($p < 0.01$). In terms of the time spent each week on the implementation of a project, 64.08% of students think that 10 to 20 h is the most appropriate and would not have a substantial impact on their study schedule and life. In terms of time allocation, students are willing to spend their time on literature reviews (28.17% of students) and experiment execution (35.21% of students), and there is a significant difference between the two groups ($p < 0.05$). See Table 3 for details.

Table 3: Students' Project Schedule and Their Thoughts

Research project	Name	Whether or not a participant took park in a medical school entrepreneurship programme (%)		Total (568)
		Participant (194)	Non-participant (374)	
The influence on one's undergraduate study and life * *	It is very influential, can improve overall ability and is helpful for graduation, evaluation of professional titles, etc.	180 (92.78%)	290 (77.54%)	470 (82.75%)
	Negative effects, takes a substantial amount of time, affects the normal study plan and life order	0 (0.00%)	30 (8.02%)	30 (5.28%)
	Unclear	14 (7.22%)	54 (14.44%)	68 (11.97%)
Specific time spent each week during implementation of the project	More than 20 h/week	36 (18.56%)	50 (13.37%)	86 (15.14%)
	15 to 20 h/week	52 (26.80%)	120 (32.09%)	172 (30.28%)
	10 to 15 h/week	62 (31.96%)	130 (34.76%)	192 (33.80%)
	5 to 10 h/week	38 (19.59%)	62 (16.58%)	100 (17.61%)
	Less than 5 h/week	6 (3.09%)	12 (3.21%)	18 (3.17%)
What did you spend the greatest amount of time on during the implementation of the project?*	Literature review	42 (21.65%)	118 (31.55%)	160 (28.17%)
	Scientific research topic selection and design	38 (19.59%)	72 (19.25%)	110 (19.37%)
	Experiment execution	92 (47.42%)	108 (28.88%)	200 (35.21%)
	Data analysis	18 (9.28%)	62 (16.58%)	80 (14.08%)
	Thesis writing	4 (2.06%)	14 (3.74%)	18 (3.17%)
* p<0.05 ** p<0.01				

Attitude Towards Sacrificing Holidays to Complete Scientific Research Training

The survey results show that 71.13% of students in the large-scale entrepreneurship group (54.01% of students in the non-large-scale entrepreneurship group) are willing to use holidays to complete scientific research training and that 25.77% (37.43% of students in the non-large-scale entrepreneurship group) are willing to receive targeted training in the process of implementation. Only 1.03% of students reject such training. A significant difference between the two groups is observed ($p < 0.05$). A total of 14.43% of the students in the large-scale entrepreneurship group (17.65% of students in the non-large-scale entrepreneurship group) are willing to sacrifice all their holidays, and 63.92% (56.15%) of students are willing to sacrifice most of their holidays. The specific results are shown in Table 4 and Figure 1.

Table 4: Opinions on Summer Training

Research project	Name	Whether or not a participant took part in a medical student entrepreneurship programme (%)		Total (568)
		Participant (194)	Non-participant (374)	
Before applying for a large-scale entrepreneurship programme, are you willing to use the summer vacation for preliminary training, including scientific research design, experimental execution, course study on thesis writing and actual laboratory work? *	Very willing to improve overall scientific research ability and lay the foundation for the development of large-scale entrepreneurship programmes in the future	138 (71.13%)	202 (54.01%)	340 (59.86%)
	Yes, but I hope that after applying for large-scale entrepreneurship programmes in the future, we can conduct targeted training	50 (25.77%)	140 (37.43%)	190 (33.45%)
	Yes, but I would like to learn professional knowledge during the holidays	4 (2.06%)	28 (7.49%)	32 (5.63%)
	No, vacation is the time to rest and relax	2 (1.03%)	0 (0.00%)	2 (0.35%)
	Other	0 (0.00%)	4 (1.07%)	4 (0.70%)
* p<0.05 ** p<0.01				

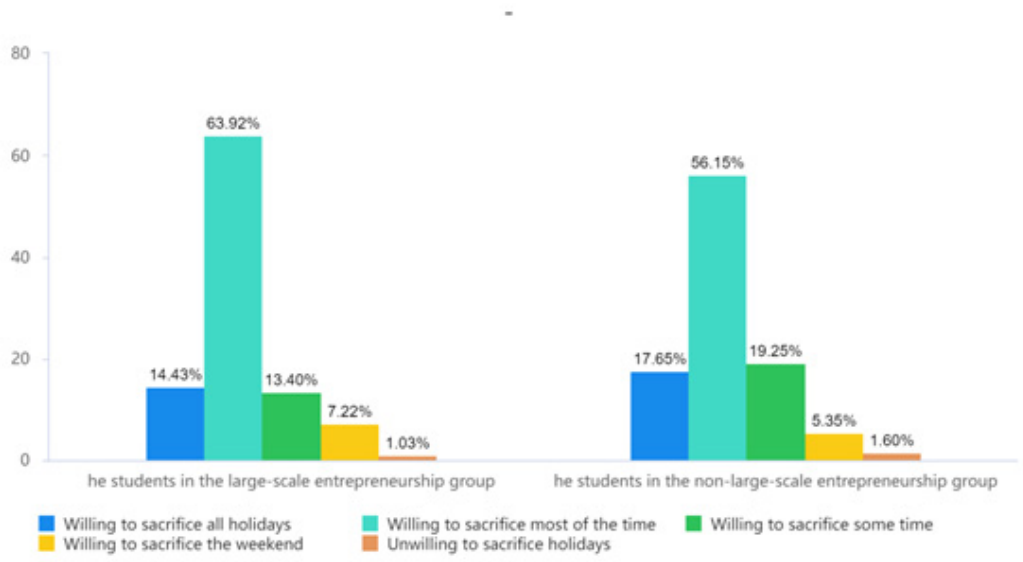

Figure 1: Views on the Time Spent on Summer Training

Reward Mechanisms

Regarding the item assessing whether or not students want to add to the scholarship programme, 91.75% of students in the large-scale entrepreneurship group do, and 75.4% of students in the non-large-scale entrepreneurship group hold the same view, but 24.60% of the students disagree. There is a significant difference between the two groups ($p < 0.01$); see Table 5.

Table 5

Research project	Name	Whether or not a participant took part in a medical student entrepreneurship programme (%)		Total (568)
		Participant (194)	Non-participant (374)	
Do you want large-scale entrepreneurship programmes to be in addition to scholarships and postgraduate programmes? * *	Yes, participating in large-scale entrepreneurship programmes will require substantial time and energy and will cause considerable pressure due to the heavy schoolwork load, so they should be used as an additional points programme for scholarship evaluation	178 (91.75%)	282 (75.40%)	460 (80.99%)
	No, I do not want to participate; during the undergraduate period, I want to focus on studying professional theoretical knowledge	16 (8.25%)	92 (24.60%)	108 (19.01%)
* p<0.05 ** p<0.01				

For the multiple choice question asking what rewards students who participate in a large-scale entrepreneurship programme should receive, 81.44% of students in the large-scale entrepreneurship group (67.91% of students in the non-large-scale entrepreneurship group) think that participation in a large-scale entrepreneurship programme should be used as bonus points for scholarship and research, and 64.95% of students in the large-scale entrepreneurship group (54.55% of students in the non-large-scale entrepreneurship group) think that participation should support the publication of papers. More than 25% of the students in the two groups prefer the former; see Figures 2 and 3.

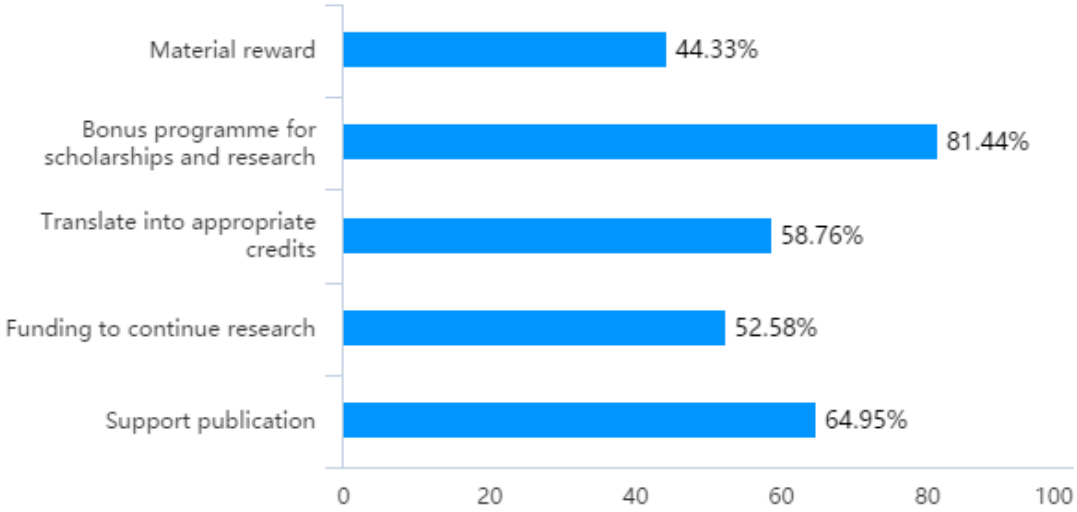

Figure 2: The Students in the Large-Scale Entrepreneurship Group - Reward Mechanisms

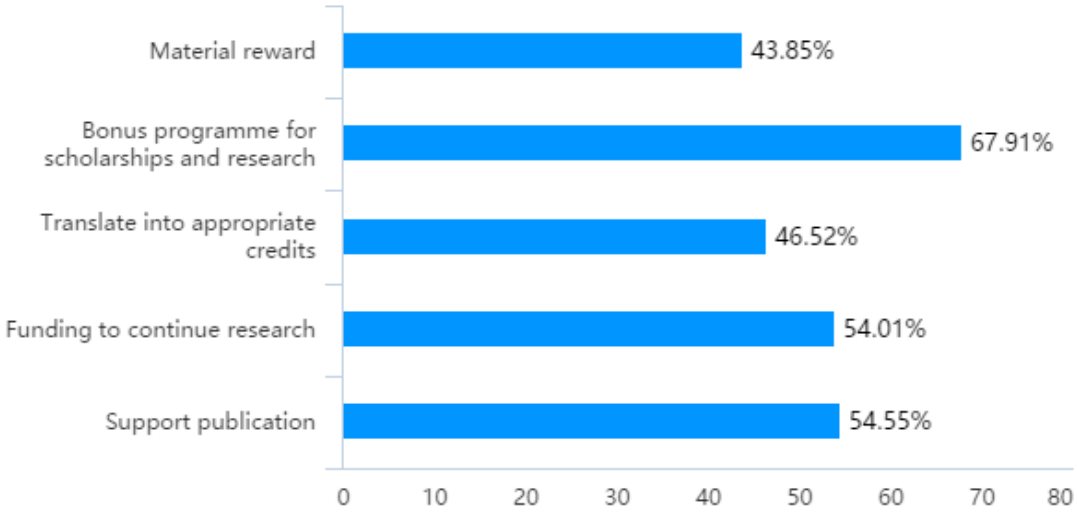

Figure 3: The Students in the Non-Large-Scale Entrepreneurship Group - Reward Mechanisms

Broadening the Experimental Platform and Integrating Experimental Resources

The two groups of students agree that opening laboratories to students can strengthen the sense of teamwork and promote the cultivation of high-quality talent. See Figure 4 for details.

A The purpose of opening laboratories is to improve the quality of teaching and to achieve the goal of cultivating high-quality talent.
B. Experiments are based on a team-based division of labour and cooperation to cultivate students' sense of teamwork.
C. Scientific research is closely related to the development of experiments, and students' rigorous scientific attitude and overall quality have been improved through the process of continuous speculation, verification and comprehension.
D. Students should experience the various experimental operations in a laboratory so that the level of teaching and scientific research can be improved through integration.
E. An open laboratory enriches and improves the structure and flexibility of experimental teaching, enabling students to innovate.

We also gained a preliminary understanding of the thoughts of the two groups of students on the operating hours of laboratories. In view of the heavy task load of medical students and their lack of time, most students want the laboratories to be open all day and hope that teachers or graduate students will be on duty for effective supervision and management. See Figures 5 and 6.

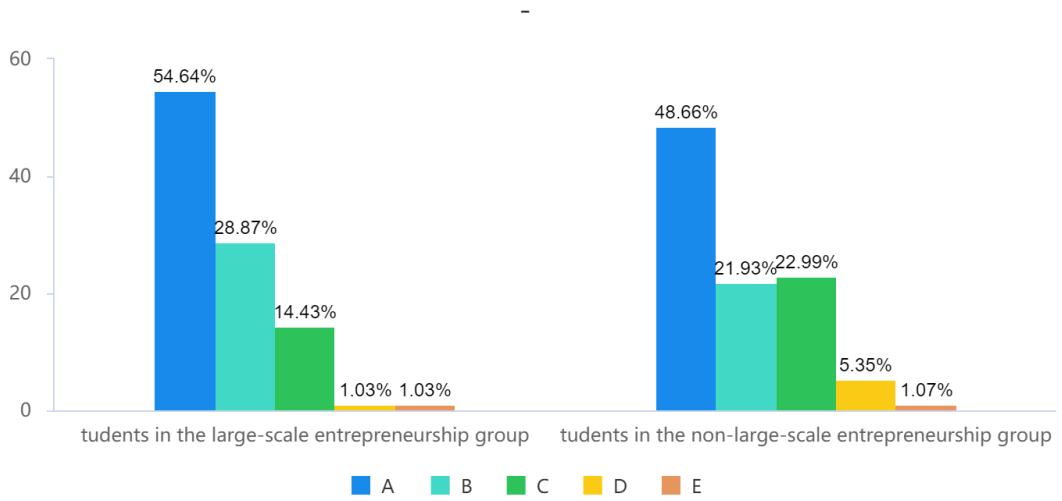

Figure 4: Views on the Two Groups Opening the Laboratories to Schools

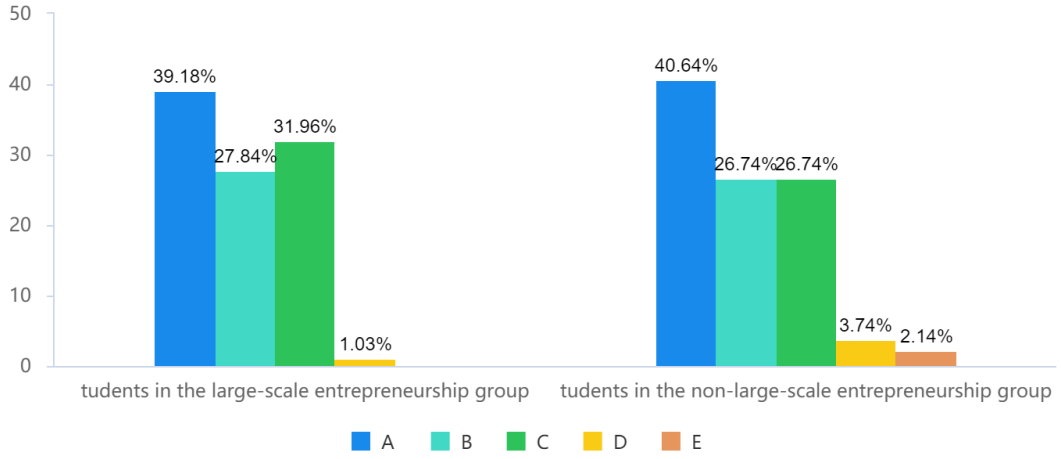

Figure 5: Views on Laboratory Opening Hours of the Two Groups of Students

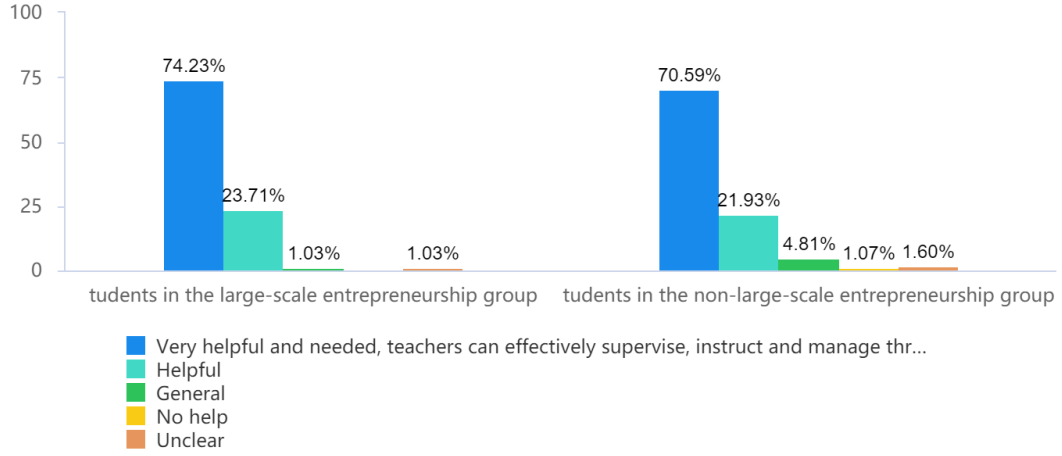

Figure 6: Views on Graduate Students Being on Duty for Effective Supervision and Management

A. Being open all day means that the laboratories are open to students all day if conditions permit.
B. Regular operating hours refer to laboratories being open at a fixed time based on actual conditions.
C. Pre-arranged operating hours refer to laboratories being open when experimenters apply to use laboratory equipment and facilities in advance and if conditions permit.
D. Staged opening refers to the practice of opening laboratories at certain stages to support the completion of students' learning tasks.
E. Other

Allocation of Scientific Research Funds

When asked how the school can improve the allocation of funds, 79.38% of students in the large-scale entrepreneurship group (65.78% of the non-large-scale entrepreneurship group) want to adjust the proportion of funds invested in national and school-level projects, whereas 10.31% of students in the large-scale entrepreneurship group (19.25% of students in the non-large-scale entrepreneurship group) think that the number of projects should be reduced and that their quality should be improved. A total of 2.06% students in the large-scale entrepreneurship group (8.02% of students in the non-large-scale entrepreneurship group) want to change the method of reporting accounts and strengthen the review process. Moreover, a total of 3.09% of students in the large-scale entrepreneurship group (3.21% of students in the non-large-scale entrepreneurship group) want complementary funding between the research groups, whereas 5.15% of students in the large-scale entrepreneurship group (3.74% of students in the non-large-scale entrepreneurship group) of students do not think that such funding is required. See Figure 7 for details.

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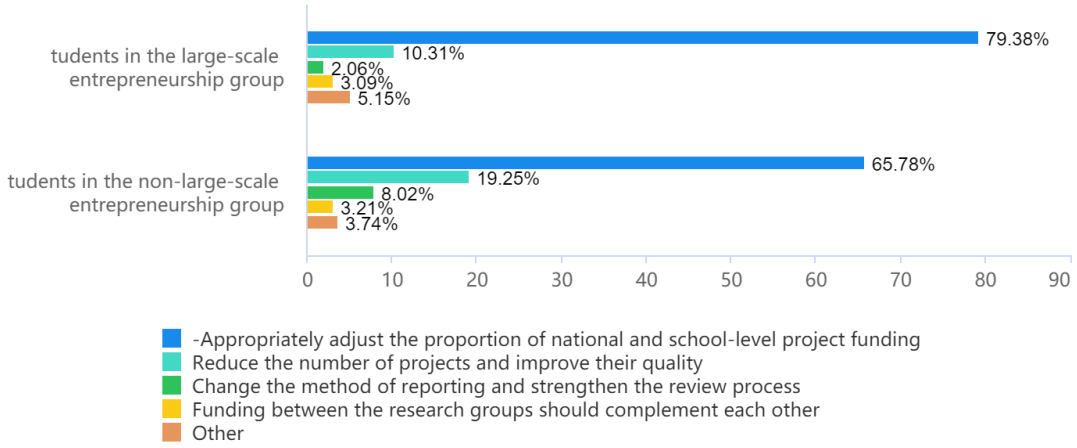

Figure 7: Thoughts of the Two Groups of Students on the School's Allocation of Funds

Discussion

At present, despite the development and specific implementation of large-scale entrepreneurship programmes, we find that higher medical education in China is still restricted by the traditional education system and that increasingly more students are aware of the shortcomings of the existing model of scientific research and training. Therefore, we must improve the existing methods of scientific research and teaching.

Improvement of Scientific Research and the Teaching Mode

Medical students currently have an unprecedented variety of ways to acquire scientific research knowledge and have a strong awareness of autonomous learning. Rather than following the traditional teaching model, students involved in research want to conduct targeted and systematic scientific research and complete training courses before engaging in large-scale entrepreneurship programmes. Some studies have found that the addition of experimental procedure courses can improve students' innovative thinking ability, which coincides with the psychological needs of our students [4]. However, their lack of scientific research experience limits their exploration of scientific research to a certain extent.

More than 80% of students hope to continuously cultivate their scientific research skills and thinking in practice under the guidance of teachers, indicating the importance of practical teaching and actively building a practical teaching system that is suitable for the cultivation of innovative talent to cultivate students' innovative spirit and practical ability. The method of teacher guidance is important in the process of cultivating students' innovative ability. When asked about their desired teaching method in scientific research courses and the desired "guidance mode" and "instructor arrangement", most of the students prefer learning through practical projects and want the teacher to participate in the project. During the interviews, the students also report that communication with the instructor is not sufficiently frequent and that a lack of guidance at important stages hinders the establishment of scientific research thinking, causing students to become "simple experimenters". This result contradicts the purpose of our entrepreneurship programme. We urgently need to improve the frequency of communication between teachers and students so that students can obtain detailed, comprehensive and in-depth guidance from mentors in the development of a project to cultivate their scientific research ability.

Moreover, in terms of the instructor arrangement, students very much want to have a "double tutoring system" or help from

the research group staff, especially students in hospital internships (which usually take place during the summer vacation of sophomore year). These students find that it is very difficult for clinical teachers to pay attention to both scientific research and clinical work, and the students want college teachers and clinical teachers to guide them together. Alternatively, full consideration should be given to the role of graduate students on the scientific research team. The "double mentor system" can strengthen communication between students and mentors, and "group help" can encourage group discussions and overcome limitations in thinking. These two types of arrangements are gradually gaining wider recognition [5].

The Creation of a Scientific Research Atmosphere. PBL, developed by the American scholar Barrows in 1969, emphasizes problem-centred, student-centred, autonomous and cooperative learning and effectively integrates curriculum learning and scientific research training [6]. However, case-based teaching combined with PBL teaching has not been applied in early scientific research training in China. Einstein once said, "Interest is the best teacher, interest is always more important than responsibility". The cultivation of an academic atmosphere can start with the cultivation of interest. The questionnaire and interview data indicate that the two groups of students believe that the two models should be integrated into scientific research training and project development. On the one hand, students' interest in scientific research can be cultivated via a large number of examples in the classroom [7]. On the other hand, instructors can conduct organized symposiums and use discussion approaches in class. The four steps of "question-self-study-discussion-solution" can be used to fully mobilize students' subjective initiative to consult the literature to understand the latest medical research information and to stimulate their interest in scientific research. Furthermore, collective discussion can stimulate students' creativity and create a strong atmosphere for scientific research [8].

Rationalization of Scheduling

The survey results show that most of the students affirm the positive role of "great innovation" in their willingness to apply for large-scale entrepreneurship programmes, but many students in the non-large-scale entrepreneurship group believe that participation will only increase their academic burden. This perceived increased burden may be one of the reasons many students decline to apply for entrepreneurship programmes. Medical courses and rotation arrangements are intense, and the actual time for scientific research is not abundant. Spare time is used to review course material and participate in scientific research training, and there is a certain degree of difficulty in this process. Therefore, the reasonable arrangement of time spent on professional knowledge acquisition and scientific research training has become a primary problem that must be solved. By establishing a long-term mechanism for scientific research practice, we can encourage and guide students who have the spare time and interest to remain in the laboratory after school to engage in formal scientific research work, improve the summer scientific research programme, make experimental plans in advance, arrange experimental personnel, and strive for students to actively participate in early rotational training without neglecting the study of basic knowledge [9]. In an investigation of summer scientific research rotational training for medical students at Shanghai Jiaotong University, Luo Deng et al found that such training not only does not affect students' daily study but can also strengthen their scientific research consciousness and skills in a short period of time. This training lays a foundation for building the overall quality of students' scientific research and innovation ability and improves medical students' scientific research thinking and thesis writing [10]. When asked about their views on a summer training rotation, more than 90% of the students in the two groups report that they are very willing to participate in summer scientific research training that would not interfere with their lives and that they are willing to spend most of their time on such training. This result indicates that students strongly support summer scientific research training.

Incentive Mechanisms to Arouse Students' Enthusiasm

Faced with the question of whether large-scale entrepreneurship programmes can be used as a scholarship evaluation programme, the two groups of students have their own ideas. After experiencing a literature review and scientific research practice, many students realize that these practices will increase their study workload, hindering interest in large-scale entrepreneurship programmes. As teachers, we not only should inform students of the importance of participating in scientific research and explain how they can arrange their time reasonably but also should consider how to improve the enthusiasm of students to participate in scientific research, perhaps by including scientific research training in the evaluation system. This measure can also increase students' attention to scientific research training. Moreover, intangible and material affirmation can be awarded to teams, such as credit recognition and bonus points for research and scholarship evaluation [11].

Broadening the Experimental Platform and Integrating Experimental Resources

Many students desire to increase the operating hours of laboratories and hope that teachers or graduate students will be on duty for assistance and support. More than 30% of the students in the two groups want laboratories to be open all day, and many students want to be able to make an appointment to use a laboratory. The students in the former group state that they have heavy workloads and want to use their available time in the evening to conduct experiments. However, keeping laboratories open at all times may cause hidden dangers to the laboratories. The needs of the students in the latter group require us to explore a more reasonable laboratory operating system. In view of this situation, we interviewed the person in charge of the experimental project and obtained a preliminary understanding of the laboratory operating system, including the training and assessment required before entering a laboratory; the open reservation platform, including daily equipment reservation information, the operating hours and the persons in charge for the day (including teachers and graduate students); and the workload and reward system for teachers and graduate students in charge of laboratories. The ultimate goal is to create conditions for the smooth development of large-scale entrepreneurship programmes.

Management of Scientific Research Funds

Although the undergraduate entrepreneurship programmes are

relatively basic, how to optimize the allocation of funds warrants in-depth research. Strengthening the management of business expenses, controlling labour expenses and expert consultation expenses, properly supervising normal business expenses such as academic conference expenses and study travel expenses, and standardizing the transfer of scientific research funds are important actions that can be taken. Additionally, student allowances must be clearly listed in the funding plan. Furthermore, the performance evaluation mechanism of scientific research projects should be improved, and a performance evaluation system for scientific research funds should be established.

Conclusions

In short, how to improve the scientific research and innovation skills of medical students is the focus of higher education research, and the cultivation of innovative talent is by no means an easy task, let alone a goal that can be achieved by training only a few students. However, through research, educators can accumulate relevant experience and create a medical education model that is conducive to cultivating medical students' capacity for innovation. This process will play an important role in promoting the reform of medical personnel training.

Abbreviations

Dacheng: College student entrepreneurship training programme.

Declarations

Ethics Approval and Consent to Participate

This study received approval from the IRB of the First Affiliated Hospital of Bengbu Medical College (BYYFY-2019KY05), and all participants provided online informed consent.

Consent for Publication

Not applicable.

Availability of Data and Materials

The questionnaire and datasets used and/or analysed during the current study are available from the corresponding authors upon reasonable request.

Competing interests

The authors declare that they have no competing interests.

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The Funder is the First Author of this Paper.

Authors' Contributions

YP: Study conceptualization and design, data analysis, manuscript drafting and revision.
WDC and LL: Study conceptualization and design
BCC and ZC: Data collection and data entry
HJY and PX: Data analysis
All authors have read and approved the manuscript.
I can confirm the personal contribution of the authors to the manuscript

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All authors have read and approved the manuscript.

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