Journal of Social Sciences and Humanities
Vol. 6, No. 3, 2020, pp. 117-124
http://www.aiscience.org/journal/jssh
ISSN: 2381-7763 (Print); ISSN: 2381-7771 (Online)

Research on the Cultivation of Innovation Ability of Mathematics Major Students in China in the Past Decade

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Abstract

At present, the cultivation of college mathematics major students' innovation ability is a hot topic. For realizing this aim, there have been many domestic pieces of researches in the past ten years. Through the literature analysis, this study finds that these researches have provided many insights on existing problems, training principles, and training measures. Existing problems are more affected by historical development and society. The training principles focus on the research of teacher teaching and student subjects. And many training measures are proposed. Many aspects such as the curriculum system, teaching content, teacher teaching process, student self-development, and school measures are mentioned, but there are fewer specific cases. The change of university students' own thoughts is a deep-level content. While the existing research mainly focuses on the changes in external conditions, there is less research on their internal thoughts. So there are many problems yet are needed to be considered in the future.

Keywords

Mathematics Major, Creative Ability, College Students, Innovation Ability

Received: March 1, 2020 / Accepted: March 30, 2020 / Published online: April 30, 2020

1. Introduction

Innovation is the foundation of a country's development, and innovative talents need to be educated. Since the slogan of "People Entrepreneurship, Innovation from Everyone" put forward by Premier Li Keqiang in 2015, innovation has become a hot topic advocated in China. On the one hand, cultivating the creative ability of mathematics major students is conducive to their innovation; on the other hand, after mathematics major students engage in education, it is also of great value to training more creative students. Scientific computing, scientific experiments, and theoretical research are the three pillars of scientific research. Mathematics plays an important role in scientific computing. Therefore, mathematics can connect with real-life, can connect students' theoretical knowledge with practical problems, and can promote students' sustainable development. Therefore, it is of increasingly important significance to cultivate the innovative ability of mathematics major students. We need to study how to better promote the cultivation of the innovative ability of mathematics major students.

At the same time, the cultivation of mathematics major students also faces many problems. For example, some researches indicate that most mathematics major students and teachers are more enthusiastic about stable work [1] and are unwilling to engage in innovation and entrepreneurship. However, whether it is the needs of an actual life or the sustainable development of mathematics major students, we should study the development of the innovative ability of mathematics major students. This paper conducts literature analysis and research on existing research, sorts out research status, research results, and existing problems, and provides a

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basis for further research in the future.

2. Research Method

The material selected for the article is selected from the CNKI, which is the most authoritative document retrieval tool for national academic journals. It basically contains all the content of Chinese journals. Based on the integrity of the resources included in this article, this article chooses this database to ensure the persuasiveness and reliability of the research. After searching the titles of "math major" and "innovation", 113 articles were obtained. After removing the articles whose research content is summarized in vocational and vocational colleges and annual meetings, and removing the innovative teaching for a certain subject and promoting the study of mathematics, in the end, 36 articles were obtained. The literature analysis method was used to analyze the screened articles, determine the author's research ideas, research process, and research results, and finally, summarize the similarities and differences among them, and analyze the results and shortcomings of existing research. After analysis, it is found that the article mainly focuses on the research and cultivation status, training principles, training approaches, and introduces the cultivation results of the author's working institution. The next step is to focus on the current situation, principles, approaches, and methods of the cultivation of innovative abilities of mathematics major students introduction of domestic research.

3. Research on the Status of Innovation Ability Training

In the research on the status, the literature believes that the cultivation of innovative abilities is not ideal. The following are divided into four aspects: curriculum content, classroom teaching, and teachers' own quality, curriculum system and students themselves:

3.1. The Content of the Course

Yang, Nie, Fan, Wang, and others all pointed out that the existing professional courses of the mathematics professional training system are too specialized, leading to the too narrow division of majors, leading to the too narrow basic courses, too specialized courses, too many required courses, and too few elective courses. Under this course content, the student's knowledge system is limited, which results in a relatively simple knowledge structure. It is not good for students to broaden their horizons, expand their knowledge and improve their overall quality [2-5]. Li, Bu and others further pointed out that the existing curriculum content is duplicative and boring. The over-specialized curriculum content leads to too many theoretical classes and the content is more abstract, which hinders the development of students' interest in learning and occupies a large amount of students' time [6, 7]. At the same time, the content of these courses is relatively slow to update. Jiang, Wang, Fan, Ma, and others pointed out that the existing courses are obsolete. The contents of the courses still emphasize the basic theory, basic knowledge, and basic skills too much. At the same time, the curriculum is too traditional, and the basic courses of "Mathematics Analysis, Advanced Algebra, and Analytical Geometry" have been basically maintained. The school offers representative courses in modern mathematics of "Functional analysis, Modern Algebra, Click Topology", as well as courses in Complex Function Theory, Ordinary Differential Equations, Mathematical Statistics and Probability, and computer basics [4, 5, 8, 9]. Besides, the updating of teaching materials should be a long-term task, and often because the content is not updated in time, students' learning content is disconnected from the actual development of society. Li pointed out that the current curriculum theory is out of touch with the lack of the introduction of typical models and cases, making it difficult for students to link real life with the content of the curriculum, hindering the development of students' innovative ability [10]. Ma proposed that the current curriculum system does not distinguish between "Mathematics" and "Applied Mathematics" as two majors to set the curriculum content, resulting in obsolete curriculum categories and hindering the development of students' innovative ability [9].

3.2. Teacher Quality Development

From the perspective of teachers, the cultivation of innovative ability of mathematics major students is first of all the lack of teachers' awareness of cultivating students' innovative ability [8, 11]. Nie, Luo, and others pointed out that the teachers of universities have a stable mentality and lack of innovative consciousness [1, 3]. In addition to the lack of consciousness, some scholars have also pointed out teaching problems. For example, Jiang pointed out that the classroom neglected to guide the discussion, interaction, and summary [8]. Luo, Sun, and Yang pointed out that there is a single method on the current course teaching. Teachers occupy the main position in the classroom. The teaching process is that the teacher continuously explains, and more of them are theoretical explanations. The teacher focuses on theoretical knowledge and problem solving [1, 2, 11]. In response to these problems, Yuan believes that the reason for such problems is the lack of professional innovation ability training teachers. Teachers often take some measures to cultivate innovation ability but have not done post-study on actual effectiveness [12].

3.3. Course Setting

In terms of curriculum setting, it is mainly the problem that the existing curriculum is subject to traditional constraints, the adverse consequences caused by the existing curriculum, and the lack of practical links between the curriculum. First of all, in terms of curriculum design, Jiang, Li, Fan, and others believed that the curriculum was constrained by traditional ideas, the system was very conservative, lacked innovation, and educational reforms lagged economic reforms [4, 8, 13]. Luo further pointed out that the innovation and entrepreneurship curriculum system are not complete, and the innovation and entrepreneurship curriculum is separate from the professional curriculum. On the one hand, it promotes the cultivation of innovative ability, but on the other hand, it is not unified with the professional curriculum, which has caused the curriculum to not keeping up with the society in time [1]. The second is the adverse consequences caused by the existing courses. Sun, Wang, and Wang and others believe that examination-based course assessment methods are likely to cause "examination-oriented education". College students are still busy with the final exams and study to pass the exams. At the same time, there is also a lack of atmosphere for students to conduct scientific research activities, and the assessment methods for students are not perfect, which is relatively simple [5, 11, 14]. Finally, there is a lack of practical activities. Fan and Wang and others raised the problems of existing classroom teaching hours, students' less time for self-study, less development of practical links, and low level of setting [4, 15]. In fact, the teachers' teaching and scientific research tasks are heavy, and the students are under study pressure. So they can't participate in the competition. This has further caused difficulties in the practical links.

3.4. Student Self-development

There is also a problem with students' own development in the cultivation of college students' creative ability. Luo, Yuan and others pointed out that some students lacked awareness of innovation education, did not pay attention to the cultivation of their own innovation ability, outdated concepts, and weak awareness. Students regard innovation and entrepreneurship as "starting a company". At the same time, according to survey data from some normal colleges in Liaoning Province, most students are affected by their parents' ideas, and they only want to work in stable jobs. There is resistance from students themselves in the development of innovative education [1, 12]. Wang also proposed that students lack their own understanding of the integrity of the knowledge structure. They have a weak awareness of using what they have learned to solve practical problems. It is also a difficulty for students in receiving innovative education and developing innovative abilities [14].

4. Research on the Principles of Cultivating the Innovative Ability

In the training of mathematics major students, domestic scholars put forward the principles of cultivating innovation ability after raising the problems of innovation ability cultivation, which are mainly divided into two aspects: starting from student training and starting from teacher teaching.

The first is to start from student training. Zhang proposed that the cultivation of students' innovative ability should be based on student interests, improve students' awareness of innovative ability, guide students to think actively, explore students' creative potential, cultivate students' mathematical literacy, and constantly stimulate students' creative spirit [16]. Zheng also proposed that in the innovative development of mathematics, teamwork is needed, but there are also genius-like innovations. Therefore, we must pay attention to developing the personality of students and students with deep insights into mathematics [17]. From the perspective of students' future development, Diao and others proposed that to meet the diversified needs of society for mathematical talents, schools should reasonably set export directions and implement a diversified talent training model [18].

Secondly, starting from teacher teaching, Zhang proposed to break teaching habits and create an open classroom atmosphere, so that students can fully express their personal opinions and views, allow students to truly integrate into the classroom, and make teaching methods and teaching content open and tolerance [16]. Zhong emphasized the great role of teachers in the training process. Because of the abstract nature of mathematics, the teachers' overall view of the curriculum, as well as good mathematical qualities and accomplishments, have become the prerequisites for the cultivation of students' innovative ability. Processing and communication with students have become key factors that stimulate student interest [19]. The above points agree with the changes in classroom teaching, attract students to participate in the classroom, and pay attention to the role of teachers in guiding students.

Gei proposed to innovate the curriculum teaching mode and adopt the practical and applied curriculum teaching mode, to innovate the classroom teaching mode, to construct a diversified and hierarchical curriculum teaching system, and to optimize the overall classroom teaching, to innovate the practical teaching system [20]. Fan also proposed to take the innovation of educational thoughts and concepts as a guide, take the construction of a school innovative education system project as a guarantee, take educational content reform and

teaching method innovation as the key, take educational model innovation as a means [4]. The above-mentioned researches all propose that teaching should be innovative in content, method, mode, and cultivate students' creative ability through teaching innovation.

5. Practical Measures for Cultivating the Innovative Ability

After putting forward some reform directions and ideas for the status quo, domestic researches further put forward specific practical measures for the cultivation of innovative ability of mathematics majors. These measures focus on the improvement of training programs and teaching models, the development and encouragement of students to participate in competitions, and the enhancement of three aspects of the practice training.

5.1. Improvement of the Training Plan and Teaching Mode

From the analysis of the status quo, we can find that the cultivation of students' innovative ability is restricted by the curriculum content setting and the number of course hours. Therefore, improving the cultivation method and teaching mode is helpful to solve the problem of cultivating the innovation ability of mathematics major students. At first, some scholars proposed that the training plan should pay attention to the needs of real life. For example, Kang proposed to pay attention to the improvement of professional literacy and information technology ability, set up statistical software courses, and improve students' ability to adapt to social development [21]. Yang also agreed with the teaching model And teaching content reform, stressing that teaching content should be updated in time with the development of society and the development of science and technology [2]. Diao, Jiang, and others believed that universities should stick to employment orientation [8, 18]. Diao and Li both cited the examples of the School of Engineering of the City University of Hong Kong, the University of Cambridge and the School of Physics and Engineering of King's College, explaining many examples of employment exports. Further, they put forward the principles of "useful, effective and advanced", constructed a professional curriculum system, advocated teaching methods and methods that focus on the subject status of students, paid attention to the quality of student resources and the future development of students [10, 18]. Jiang also proposed to adhere to the employment-oriented, adjust curriculum settings and teaching content, and further proposed to persist in serving local socio-economic development and broaden the idea of running a school [8]. Wang and Dong both proposed that the goal is to cultivate applied talents, improve the quality of classroom teaching, reform the curriculum system, change some courses to electives, and let students choose courses according to their own needs [6, 15]. Both Ma and Zhang attached importance to the development of students and proposed to establish the student's subjective status, give play to the student's subjective role, stimulate students' creative consciousness, and cultivate students' innovative personality qualities [9, 22].

In terms of specific training methods, domestic scholars have proposed some measures. For example, Li proposed a teaching method to infiltrate scientific ideas through the classroom. Exercises are used to exemplify this infiltration. In the article, infectious disease models are used as examples. Broaden the conditions of the problem and make it closer to real life. The article provides a case of developing students' creative ability and linking mathematical knowledge with real-life [23]. Luo also proposed to strengthen the innovation and entrepreneurship education curriculum system through idea penetration and idea penetration [1]. Wang even put forward to writing a series of postgraduate teaching materials that have certain characteristics, frontier knowledge update, and creative ability training, which are suitable for the requirements of talent training in his school [24].

Sun, Zhai, Tian, Li and Yuan all believed that attention should be paid to thinking training and problem awareness. Sun proposed measures to use the teaching process to develop innovative abilities, such as showing students innovation in teaching materials and appropriately expanding mathematics teaching content. The process of mathematical creation is demonstrated in teaching, and analogies, associations, and divergences are emphasized in teaching to stimulate students' problem awareness and allow students to learn to find problems and ask questions [11]. Zhai proposed to create a good objective environment for students, attach importance to the teaching of knowledge principles, advocate discovery education, strengthen divergent thinking training, and be good at discovering and developing students' personalities [25]. Tian and Yuan both proposed to cultivate students' reverse thinking in mathematical reasoning and cultivate students' original abilities in problems [26, 27]. Yuan also believed that the dialectical relationship between teaching without class and teaching by aptitude should be properly handled. Li believed that teachers should strengthen the self-study of students, choose typical mathematical knowledge or problems with strong divergence, and attach importance to the development of students' image thinking, divergent thinking and intuitive thinking [28]. Li also attached great importance to the quality of the teacher team, and proposed to build a group of teachers with innovative thinking, established a curriculum system suitable for training innovative talents in mathematics, and

showed the characteristics and application areas of each specialty to students through teachers [29]. Ma believed that teachers should have a high level of forward-looking thinking, which is compatible with the profound knowledge of science and humanities [9]. In terms of teachers' teaching methods, Yang and Yuan both believed that teachers should pay attention to guiding students in teaching methods, allow students to think time, respect and encourage students, and gradually guide students to properly view the cultivation of innovative abilities [2, 12].

Concerning the improvement of the training model and training method, Liang proposed to explore the "151" training model of innovative talents in mathematics with "thick foundation + heavy literacy" [30]. Wang also proposed a talent training model "student-oriented, task-led, ability-based" [24]. Jiang and Ge both pointed out that they must adhere to the teaching method of teaching according to their aptitude. Jiang proposed to achieve dislocation development, strengthen the application ability and autonomous bachelor, and stimulate students' initiative to learn [8]. Ge also proposed a practical hierarchical training plan. Strive to achieve the best possible talents, organize mathematical modeling activities hierarchically, and organically combine the improvement of teachers' scientific research level with students' research-based learning to cultivate students' research level to achieve the development of students' innovative ability [20].

5.2. The Role of Scientific Researches and Competition Activities

Because the competition exercises are close to life, encouraging students to participate will help students connect theoretical knowledge with real-life and cultivate students' creative ability. Wang proposed to optimize the professional experimental curriculum, promote college students' innovation and entrepreneurship training programs and competition activities, summarize the competition experience in time, and further promote the reform of mathematical modeling and mathematical modeling experiment teaching with the results of participating in mathematical modeling competitions [5]. Wang also proposed to use subject competitions and scientific research projects as the carrier and support to stimulate creative thinking and cultivate students' creative ability [15]. Wang put forward some specific implementation measures, such as conducting special lectures and discussion classes to allow students to participate in teacher projects [14]. In creating a scientific research atmosphere, Liu also proposed to create an innovative environment. The school enhances students' innovative behavior by establishing specialized study groups, conducting assessments and competitions, and encouraging students to participate in scientific research activities [31]. Similarly, Xie proposed a group cooperation method to promote students' participation in competitions. He also noted that attention should be paid to creating atmosphere through lecture introduction, extensive publicity and other methods, providing funds and environmental facilities, forming rules and regulations on management, and maintaining groups' interest orientation, continuity, and development [32].

5.3. The Training of the Practical

According to the analysis of the status quo, at the present stage, there is less practical curriculum arrangement for the cultivation of innovative ability of mathematics major students. Therefore, in the way of carrying out internship teaching, Kang proposed to expand the students' innovative practice platform by carrying out innovative competitions [21]. Bu also proposed to pay attention to the role of platform creation [7]. Through the two platforms of mathematics competition and modeling competition, students participated in it and achieved good results, which shows the importance of the practice platform. Li suggested that by adjusting the ratio of practical courses to theoretical courses, the comprehensive practical level should be appropriately increased, and the feedback of students in practice should be heeded [13]. Ge believes that the construction of internship bases should be strengthened so that students can train for internships and carry out full-time vocational training [20]. Ling proposed a problem-driven practice teaching model, using modern teaching methods for teaching practice training, such as electronic whiteboards, microteaching and other equipment [33]. In response to specific measures, Li proposed a "3 + 1" single course design system for basic knowledge, extracurricular materials, cutting-edge information, and case models [10]. Li and others proposed to strengthen practical teaching links, learn some courses needed in practical applications through courses, and train students in the way of practice bases [34]. Wang especially proposed to add "Basics and Applications of MATLAB", "Mathematics Modeling Experiment", "Statistical Analysis Software" and other practical courses [5].

5.4. Evaluation Methods

Under the current training model, the study of student learning is mainly based on the final exam results. However, as pointed out by scholars, this type of examination is likely to lead to "examination-oriented education". Students learn knowledge only to pass the exam and do not pay attention to the development of their literacy. Therefore, it is necessary to reform existing assessment methods to change this situation. Kang suggested that through the establishment of student scientific research projects, innovation should be incorporated into the evaluation system of students and teachers, and the

results should be incorporated into the study of student progress and employment, to provide a good atmosphere for scientific research innovation [21]. On the improvement of the evaluation system, Li believes that the method of evaluating students should be suitable for examining students' practical application ability [29]. Gou suggested that the evaluation work should comprehensively consider the test results of students, find problems in practice, analyze problems, solve problems, improve students' practical ability, and use the incentive mechanism to promote teachers and students to participate in scientific research projects [35]. Li and others proposed to implement and improve the multi-level teaching management and quality evaluation system, such as the initial, intermediate, final, and daily inspection methods. [34]. Wang proposed strict management of the thesis process to reform and improve the evaluation system [5]. Wang believed that the graduation thesis should be paid attention to because it is a method of cultivating students' scientific research consciousness [14]. Different from undergraduate education, Wang proposed to strictly control the master's degree thesis from the graduate education, starting from the three topics of question opening, mid-term inspection, and graduation defense [24], focusing on training graduate students' innovative ability.

6. Discussion

From the research of the last ten years, most scholars have studied the current situation of the cultivation of innovative ability of the existing mathematics majors. Through researching the training mode, it is found that there are four problems in the content of the curriculum, the curriculum system, teacher teaching, and the students themselves. Based on the existing problems, the reform principles have been studied. Most scholars have proposed their own measures in the article. In some researches, the authors introduced the measures taken by their schools and showed the results achieved.

Existing researches analyze the existing problems, and the problems are closely related to the social background. In terms of curriculum content, on the one hand, the society is advocating or even requiring schools to train students with innovative mathematics majors, but on the other hand, the school's curriculum content and curriculum system ~~still~~ continue the previous content and have not been improved according to actual needs. The content of major courses in mathematics is more difficult, so students spend more time on these courses, which hinders students' personality development to a certain extent. Teachers' own research pressure and teaching tasks, including student learning, are not willing to change because of "stability". This concept has led students to alienate challenging and innovative courses and learning content. They like to study the "unchanged" content. The purpose of learning is to pass the exam, not to improve their own cultivation and cultivate their innovative ability to better adapt to society.

Some domestic researches have put forward the training principles and ideas. From the research of the past ten years, it has become a consensus view to cultivate students' creative ability and take students as the main body. The ability to innovate is the ability that students should have in their future lives, and it is the need for students to actively seek development. Teachers' teaching should also support students' development. Therefore, breaking the traditional teacher's teaching knowledge, and the mode of students receiving knowledge has also become a research consensus. Students take the initiative to ask questions, and the teacher promotes students to participate in the classroom. Through the guidance of interest, the two processes of learning and teaching are changed. It is worth mentioning that most of the existing research is to promote the development of the current mathematics majors, and Han has proposed research ideas to train "prospective teachers" [36]. Now that more mathematics major students eventually take up the teaching profession, the cultivation of "prospective teachers" innovative ability also promotes the innovation of future students, so the cultivation of innovative ability is of great significance.

Most domestic researches have put forward implementation measures for the cultivation of innovative capabilities, and the specific content still needs to be deepened. The study proposes to adjust the curriculum system of students in the context of realistic needs, such as converting some of the more difficult compulsory courses into elective courses. Students can choose more courses that meet their needs, which can promote students' independent development. Teachers pay attention to enlightenment and guidance to students in teaching, arouse students' interest by broadening the curriculum content, and attach importance to the cultivation of students' thinking ability in teaching. In these researches, Li Kun used a practical example in the article to show how the mathematical model of infectious diseases learned by students is approaching real-life step by step under the conditions of continuous relaxation. Similarly, other scholars have proposed some measures and proposed some training models, but it is difficult to see specific operation methods and actual examples in the article, so it is difficult to borrow examples to learn these models. Although existing research has proposed some measures, students have won awards in various competitions, but they still need to verify the relevance of specific cases.

Participating in competitions, participating in scientific research projects, conducting practical training and reforming the evaluation system are all important ways to cultivate

innovation ability. Competitions and scientific research projects require students to make certain innovations based on the content of the learning curriculum. Therefore, it is necessary to cultivate innovation ability in the process of solving innovation ability. The practice in the research focuses on the two substantive exercises in teaching and educational practice. This is to make students not only cling to the theoretical study but also to do it manually. "What upper-level people like, lower-level people will learn more about what they like". It is undeniable that the evaluation method greatly affects the students' learning goals. When the course assessment method is only the final exam, students aim to pass the exam. Similarly, changes in evaluation methods will attract students to change their goals. With the integration of evaluation methods, students will necessarily improve themselves comprehensively. However, the changes in the evaluation system must also be coordinated with the reform of the curriculum system, otherwise, students will be overburdened and deviate from their original goals.

7. Conclusions and Inspirations

After analyzing the existing research, the following conclusions can be drawn:

(1) There is a lot of consensus on the research of existing issues, and it reflects more on the issues of curriculum setting, curriculum content and teacher quality, but there are also cases where the research on students' own problems is less. Although the research on the status quo is comprehensive, there is less research on the ideological issues of students' own development, and the empirical research data is insufficient.

(2) In terms of training principles, existing research agrees that training methods should be improved from both the teacher and student directions. Researches need to explain more clearly why teachers and students should be the starting point.

(3) In terms of specific training measures, domestic scholars have proposed more methods, focusing on the improvement of training programs and teaching, encouraging participation in scientific research projects and competitions, promoting the practice and reforming the evaluation system. The domestic scholars' research is highly theoretical. The idea of some articles is to give measures and then show the results achieved by the author unit, but the degree of correlation between them has not given a clearer explanation.

(4) In fact, after proposing such a large number of schemes and measures, as researchers, we still do not know the advantages, disadvantages and applicable conditions of the schemes. Therefore, although the existing research provides us with broad research ideas, we still need to continue to study in-depth. Although schools should take responsibility for guiding students' future development, students should think about their future development. Therefore, how to make students realize this and help them is what future research needs to do.

Funding

This research was supported by the Shandong provincial education department grant number is SDYY17127, and the Shandong normal university grant number is 2016JG29.

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