

## **Cultivating the innovative ability of college students**

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**ABSTRACT:** With the rapid development of knowledge and information economies, innovation has become the theme of the times. For China to stand tall among the strongest future nations, the country's economy ultimately must rely on a long-term commitment to innovation in science and technology. In order to improve the capability for independent innovation and to build an innovation-oriented country, it is necessary to enhance the ability for continual innovation in science and technology and, especially, to improve college students' ability to innovate. Combined with the status of college students' innovative ability in China, the authors have analysed the causes that hinder their ability to innovate. This focuses on strengthening ideological and political education, as well as adjusting course structure and teaching content, leading to a solution covering five aspects. The results presented in this article provide an important reference toward cultivating the innovative ability of college students, and for educational and teaching reform.

### INTRODUCTION

Nowadays, with the rapid advancement of science and technology and increasingly fierce competition among countries, technological innovation has not only become a strong lever promoting economic growth, it is also a core factor in creating competitive advantages for each country. In recent years, close attention has been paid in China to the development of science and technology, by advocating realism, pragmatism and innovation, thereby accelerating the development of an innovative country, achieving innovation-driven development. Higher education is the cradle of cultivating innovative talents, and the foundation of the national innovation system. In the 21st Century, the mission of higher education is to cultivate innovation-oriented talents. In the reformation of higher education in this century, the cultivation of innovative talents is one of the main goals of education reform in various countries. Thus, Chinese higher education also should accept the historical responsibility for cultivating innovative talents. In school, cultivating and training students' ability to innovate in scientific research and technology will be most important for the development of the nation, its cultural identity and for the students themselves.

Many domestic and foreign experts, as well as scholars, have reported on, and demonstrated from different perspectives, the innovation process leading to a relatively mature theory. They had also made a detailed analysis of the reasons for the current lack of college students' creative ability. However, few have produced practical solutions for implementing teaching reform involving the concepts or training methods to cultivate innovative talents. Therefore, and authors' aims in this article are to propose a system, adapted for China, that combines the training system and mode together with the operational mechanisms for promoting college students' technological innovative ability.

### CURRENT SITUATION REGARDING STUDENTS' CREATIVE ABILITY

#### Students Lack of Knowledge and Understanding of Innovation

Through a questionnaire distributed to 576 students at a school, the authors found that the majority of the students strongly affirmed the importance of innovation and believe that innovation is an important quality to possess (Figure 1). They desire to develop in this area and are eager for the college to pay more attention to their innovative ability. However, students who believe they have some ability to innovate number fewer than half the total, which suggests that college students' innovation ability is relatively weak and needs to improve. More than one third expressed uncertainty about their ability to innovate, which reflects a weak conscious awareness to innovate among contemporary college students (Figure 2). It also shows a lack of a good understanding of themselves and how they understand innovation. In addition, the authors found that college students prefer innovative ability over practical ability. This is a key point and can act as a pointcut in promoting and enhancing the education of innovation ability [1].

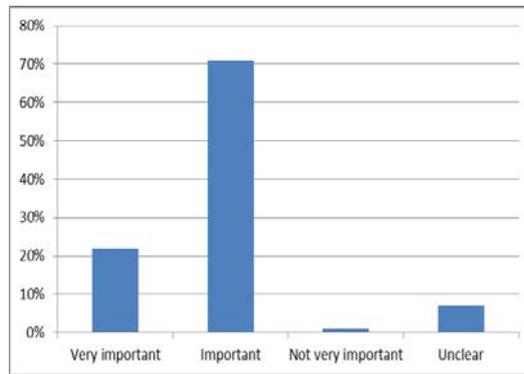


Figure 1: What do you think about the influence of innovation ability on your future development?

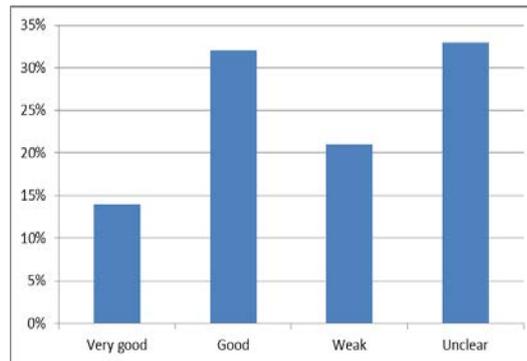


Figure 2: How do you evaluate your innovation ability?

#### Students' Lack of Confidence in Innovation and Perseverance

Students already have some conscious awareness of innovation gained from years of learning, but they also possess a general lack of confidence and willingness to innovate. Innovation requires curiosity, hobbies, skepticism, a spirit of challenge and so on. At present, although students have these basic factors and are often able to show some innovative inspiration and impulses, once these are initially put into practice, they give up further implementation for various reasons. For example, learning makes them too nervous or they are too bored to find information or testing is too costly or it is too much trouble to ask teachers for help. There can be a series of causes for this situation e.g. a lack of confidence or of independence or of initiative or of practical work during the early stages of innovation. These, combined with a lack of ability and willpower and, perhaps, an anticlimactic feeling after the initial stages of innovation, have become common issues in considering college students' creative processes.

#### Students' Lack of Clear Goals Toward Innovation

Setting goals for people requires preconceived activities and plans. This means being prepared to make the effort to pursue by objective criteria the subjective vision they hold of the desired outcome. A clear and appropriate goal is a powerful driving force to learning. Students who have strong goals can consciously and actively pursue learning and continue to forge ahead toward their goals. Other students who lack clear targets have few daily activities to occupy them and muddle along aimlessly. Hence, they lose their enthusiasm for learning, and do not have a spirit of hard work and wonder whether or why they should learn. After graduation, they find themselves thinking it was all just a waste of time. Through learning and accumulating knowledge during school, students retain a certain enthusiasm for innovation. But due to the lack of communication and comprehension of society, they lack the clear goal of innovation.

#### Traditional Mindset Still Hinders the Development of Students' Innovative Ability

A mindset is where people's thinking is fixed and limited. People learn from the environment around them and, over time, they form a fixed pattern of thinking. People are accustomed from a fixed angle to observe and think about things and, in a fixed way, to accept things [2]. The mindset for familiar problems can make them skilled at quickly solving these problems. However, in the field of scientific research, people often have to deal with very unfamiliar, even hitherto unknown, conditions of a problematic situation, making it necessary to use divergent thinking and to try different solutions. Thinking within a mindset can restrict the production of new ideas and new methods, leading to logical degradation and a poor solution to a problem. This could be a serious obstacle to the essence of innovative thinking.

The underlying survey carried out by the authors show that the contemporary university student has the capacity to think seriously, but when they encounter a problem, they are accustomed to using their familiar ways of finding a

solution [3]. As personal experience grows and their knowledge base builds, the development of their ability to think in terms of logical reasoning is rapid. But in quick-thinking with logical rigor and clarity, there is a declining trend in their use of imagination. At the same time, due to the limitations of teaching plans, college students do not get a wide enough range of knowledge across all subjects many of which are mutually independent and unrelated. If students cannot sort out and integrate the knowledge necessary to problem-solve and innovate, they will not achieve the desired mastery of the required knowledge, leading to the strange phenomenon of *not seeing the wood for the trees*.

## ANALYSIS OF THE FACTORS HINDERING THE DEVELOPMENT OF STUDENTS' INNOVATIVE ABILITY

A lack of innovative ability has many complex reasons. Due to the effect of the social and cultural environment, the problems of school education and the lack of students' understanding, as well as for other reasons, scientific and technological innovation are absent from solving the many problems faced.

### Long Term-Oriented Education Training Mode Causes Students to Value the Theory but Ignore Practice

Chinese students must pass a tough college entrance examination which can be an impasse. Examination-oriented education evaluates students based on this sole criterion. Education is aimed at developing the ability to cope with various examinations, and the imparting of knowledge and acquiring problem-solving skills, while also valuing the application of knowledge [4]. At the same time, it often adopts methods, such as excessive learning and intensive training. This confines the study to a range of textbooks while ignoring the students' practical hands-on ability. This leads to students lacking time and enthusiasm for participating in activities outside the classroom.

Hence, this results in a narrow range of knowledge which can produce high-scores but with low-ability. Students who do well under the long-term oriented education regime have obvious advantages when it comes to sitting for examinations. However, their practical ability and innovation ability are lagging far behind Europe and other developed countries. Heavy theory and light practice dilute the students' conscious awareness of practice and exploration. Although they are quick thinking, they may also lack creative thinking ability.

### Instilling Education Causes Students to become Accustomed to Learning Passively Rather than to Initiating Exploration

At present, the main teaching mode in colleges and universities is instilling of material or the memory-teaching mode [5]. This traditional, passive mode of teaching is an obstacle to college students in showing their initiative and innovation ability. This leads to a lack of willingness and effort not only in students' wishes to innovate, but also in their actions. It seems they are also short of a sufficient sense of urgency. Over time, multimedia teaching has been applied widely in various universities, and it plays a role in improving students' interest in learning. However, practice has shown that, for most teachers, multimedia more often is used instead of the blackboard, to save time spent on writing in the classroom, so that students can acquire more knowledge in each lesson.

However, in other areas, little has changed. Because the number of teachers is insufficient for the number of students, amongst other reasons, the teaching is still the instilling mode. This makes students accept knowledge passively, which is not meaningful in a wider sense. Students barely remember the teachers they encounter during the process of acquiring knowledge through note-taking and rote learning, and usually they do not know the origin of the knowledge. They still do not reach out to grasp the degree of flexibility required in applying that knowledge, and that is a serious impediment to students' creative thinking and development of innovational behaviour.

### Scientific and Technological Innovation: Inadequate Investment in Human and Financial Resources Restricts the Cultivation of Students' Innovative Ability

The necessary funds, space and laboratory equipment are important in carrying out scientific and technological innovation. Currently, college technological innovation activities rely on an administrative allocation from the school. Some national key universities and colleges of the Ministry of Education possess better conditions than do other schools. Therefore, they may allocate more expenditure to these kinds of activity. However, some provincial schools' expenditure on the education is not nearly enough in terms of funding, not to mention other spending. The shortage of money means there is no guarantee of adequate materials. Such a shortage of material restricts to a serious degree the students' level and quality of scientific and technological innovation. Meanwhile, because the incentive mechanism is imperfect, there is a great lack of strength in instructions in science and technology innovation, with even the technical support not guaranteed. This leads to a low success rate in technological innovation and poor content.

## WAYS TO IMPROVE STUDENTS' INNOVATIVE ABILITY

### Strengthen Ideological and Political Education, Training Students in the Spirit of Technological Innovation

As an entry point to cultivating students' innovative ability, ideological and political education can not only guide students toward establishing the right conception of world, values and life, but also will arm them with the idea of scientific knowledge. Ideological and political education teaches students the theory of innovative activities and helps

them to develop a critical approach and the ability to think independently. Ideological and political education should develop students' creative abilities consciously and with conscientiousness. Mainly, the course content should encourage firm ideals and beliefs, a spirit of respect for the scientific knowledge, a vivid imagination, the courage to dare to criticise others, and so on.

For students, it is impossible to carry out in-depth investigations because of the long-term nature of campus life. With a shortage of social understanding, the young are easily confused by all kinds of ideas and may develop all sorts of wrong modes of thinking. Therefore, the concept of teaching ideological and political education should be changed, in order to provide the students with more practical opportunities. This can help them to improve their skills in analysing and solving problems, while becoming more mature and stronger, with a correct perspective on frustration encountered during innovation, thus, improving their ability to resist setbacks and adding value through quality.

#### Adjust the Curriculum System and the Teaching Content to Meet the Requirements of Developing Students' Creative Ability

In adhering to the principle of *the thicker the foundation, the more the opportunities*, the curriculum system and teaching content in schools should help students acquire wide, solid and basic knowledge. Innovation capacity is not a tree without roots, so this creative subject should be built on wide knowledge and theory. The foundation of skilled knowledge should not only include the humanities, social sciences and natural sciences, but also consist of professional engineering and technology knowledge, the basic principles of many subject, and core theories where the ideas and methods of analysis and problem-solving are most important.

With the development of technology, different subjects are no longer isolated from each other, and it has become an important feature of modern engineering disciplines that they interact with each other, often in cross-disciplinary ways. They may even get inspiration from each other, while developing closely together [6]. The course and teaching content should develop over time by integrating different subjects, expanding students' professional learning horizons, while inspiring students' curiosity to explore this unknown *space*.

This should enhance the students' professional learning and their interest in attempting new things. Through the intersection of related subjects on shared issues, insights and deliberations, the undergraduates can be inspired to generate new views which, in turn, can develop new ideas and provide different views of innovation. Teaching programmes are designed to protect the students' pursuit of professional learning, while meeting their interest in learning and developing their curiosity of the unknown world. This provides the students with various opportunities for developing their own personalities.

#### Deepening the Reform of Experimental Teaching Through the Laboratory

Practice makes perfect. The laboratory is not only the place where students practise theory and identify conclusions after exploring the process; it is the carrier which contains personnel training for colleges and universities, for scientific research and knowledge innovation. Teaching with experimentation helps students to strengthen the knowledge gained in class to cultivate practical ability and to stimulate innovation. It plays an irreplaceable and important role in improving the quality of students and the *growth* of students.

Universities should be strict with the selection of experimental teaching programmes. The number should be increased first and the quality will follow. Teachers should design pilot projects carefully to void imitative experiments [7]. What they do should guide students to think seriously and to conduct careful analysis. At the same time co-operating with others and discussing work stimulates interest in participating in the experiment. Teachers can measure the topics relating to the pilot projects and modular experimental projects, so that students can learn the importance of a designed programme, of data measurement, of summarising the lessons of failure in the experiment, but also the satisfaction of success and knowledge gained.

Teachers can also launch pilot projects that set insightful questions to attract students' interests, gradually guiding them into the experiment, and expanding the in-depth experimental content in the process of developing students' good habits of hands-on experimentation and practice. Through a series of project topics in a designed programme covering theoretical analysis; component development, simulation and production leading to final commissioning, students can change from a focus only on test scores and pay more attention to the study process, which enhances the learning initiative and significantly improves students' scientific spirit and practical ability. It is most important to carry out meaningful experiments regularly. This not only helps students to gain experience and master knowledge, but it also can enhance their flexible capacity for innovation and generate a passion for student innovation.

#### Organise More Extensive Technology and Innovation Contests for Students

Science and technology competitions are an important means by which to enhance students' awareness of technological innovation and bring the spirit of challenge, and students' competitive sense into play. This requires students to mix basic and professional knowledge, and apply this to analysing and solving practical problems. Participating in science

and technology competitions can guide students in establishing the concept of innovation, while stimulating their passion for creation. It enables them to practise a creative approach, while fostering a spirit of innovation, and the development of independent learning. It helps them to think divergently, discovering issues and accumulating scientific knowledge.

Currently, both national and provincial organisations have carried out a variety of *Challenge Cup* programmes to provide a lead for college technological and innovative activities. This has become an important part of campus life. These have become a main vehicle to attract students so as to cultivate the spirit of experimentation and innovation, thus, providing an indispensable platform to attract *bright* people to training innovation [8]. It is a complicated systematic project for a student science and technology innovative contest to operate well, and it needs a great commitment by leaders in universities, related policies of colleges and enough funds to launch.

The support of every functional department is needed to intensively spread this idea, as well as the students' desire to participate. All of these parts need to be mobilised and organised carefully. Schools should take the science and technology innovation contests in which students participate, as a meaningful method of enhancing the quality of the training to develop brilliant people. Effort should be made to encourage the full mobilisation of students to participate with maximum interest, and to encourage teachers to see it as their duty to patiently guide students in science and technology activities.

#### Advocating Excellent Students to Participate in Research Projects

In cultivating cutting-edge talent, schools should teach individually and encourage students with a solid foundation, quick mind and good practical ability to take an active part in the teacher's major research projects. It is an important way by which students can enhance their innovative ability and discover their potential for innovation and to participate in scientific research. In specific scientific experiments, students are exposed to the forefront of industrial technological knowledge and unresolved technological problems. This helps to open up horizons and stimulate enthusiasm for learning. Students should actively participate in laboratory research work, which not only increases their practise and thinking ability, but also can let them accept the guidance of the scientific research host teacher, and is conducive to rapidly improving the student's quality [9].

For students who have extra ability in learning new knowledge, it is possible to involve them in systematic research training to let them practise personally in an experiment as the research assistant, to make them apply the theoretical knowledge from books, so as to understand the practical problems raised by experiments, and to solve them through their observations and thinking carefully. They can learn how to check information from scientific documents and also to learn about domestic and foreign advanced scientific and technological achievements. In this way, they can develop their creative thinking capacity effectively, as well as cultivating their scientific spirit of seeking truth from facts. It also develops their ability to think independently and to form judgements, while creating a higher level as a starting point for future development.

#### Improve the Mechanism of Construction and Ensure Sustainable Development of Science and Technology Innovation

Improving the technology innovation capability of college students is not independent of the university's attention and support. Every university should create corresponding policies and measures on aspects of capital, sites, equipment, supervision and so on, to establish a well-constructed scientific and technological innovation protection and incentive mechanism and, then, efficiently make it come to fruition.

First, it is necessary to establish a science and technology innovation incentive mechanism for college students. Then, use the students' intrinsic motivation, to set a clear and meaningful goal by which to guide students' actions. This should be capable of completely raising students' enthusiasm for science and technology innovation activity and creativity.

Second, it is necessary to develop the faculty adviser's standing by listing their teaching activity on guiding the students in science and technology innovation activities, in the content of their title, position and performance evaluation and, then, increasing it gradually. An improvement is required in the teacher's reward scheme on reforming the curriculum, and science and technology innovation education to fully mobilise the major teachers' enthusiasm, and to promote in depth and breadth students' science and technology innovation activities.

Finally, it is necessary to establish for college students a management system in science and technology innovation activities to ensure these can be conducted continuously, and in an orderly way. A fund management system should be established to ensure the rational use of funds. A science and technology achievements registration and reporting system should be built. Students who apply for a patent should be funded. College students' intellectual property rights should be protected. An application management system should be established of the science and technology achievements' innovation, transformation and promotion. Students should be guided to actively participate in the achievement, commercialisation and productivity outcomes to achieve the economic value and social value of technological achievements.

## CONCLUSIONS

Innovation is the core quality of scientific and technological talent; the core competition advantage of the development of an enterprise; the soul of a nation's progress and the inexhaustible force motivating toward national prosperity. As the main outlets for cultivating innovative talent, colleges and universities must be bold and assume this historical mission, to deepen educational and teaching reform, and actively build a broader platform for the cultivation of students' innovative ability to train more excellent builders of, and successors for, a well-off society and realising the great rejuvenation of the Chinese nation.

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