



# Cultivating Strategies of Creativity for College Physics Students

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## ABSTRACT

Creativity plays an important role in learning and life for undergraduates who major in physics. There are many factors in physics help teachers to train students' creativity. Teachers should have advanced education ideas about physics creativity education. There are several methods to foster students' creativity in physics instruction, such as strengthen the training of creative thinking, implement experiments and scientific practices, and grasp the principles of creativity.

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## Introduction

Physics is recognized as one of the important subjects for developing students' creativity. The teaching objectives of physics are to enable students to master the basic theory of physics, have good experimental capability, apply their knowledge to solve physics problems effectively, and cultivate the students' exploring spirit and innovation consciousness [1]. Creativity is an important part that constitutes the ability of students in physics specialty and it is significant to ensure that the students can make excellent achievements when they engaged in professional work or other important guarantee for future work. Creativity has been characterized by divergent thinking and measured in terms of the fluency, flexibility, and originality of ideas produced [2].

Physics creativity is the ability that students create a novel and unique product with personal value or social value from physics phenomenon, process and fact. It is a kind of comprehensive ability that is developed based on observational ability, experimental ability, ability of thinking, self-cognitive ability, etc. It can be manifested in observation and experiment, as well as in learning professional physics knowledge, solving physics problems and scientific practice and so on. Possessing with good creativity can help undergraduates to master the professional knowledge of physics and develop their science literacy.

### Cultivation strategies of Creativity for students major in physics

In order to teach for creativity, physics teachers need to know how doing it effectively [3]. In physics, there are abundant factors for cultivating college students' creativity. If all kinds of effective measures are adopted to cultivate students' creativity, it not only promotes the quality of classroom teaching, but also improves the quality of physics talents training.

### Establishing the correct education concept of physics creativity and contrasting harmonious teaching atmosphere

In the teaching process of professional courses, teachers should cognize the relations between creativity and intelligence correctly. Some psychological studies show that the developments of creativity and intelligence are not synchronous and intelligence above general level is necessary for realizing creative potential; however, if the intelligence is above the

critical level of students, the relevancy between intelligence and creativity is almost zero [4]. The college students with creativity always show a strong thirst for knowledge, trait of thinking, independent personality (such as spirit of suspicion, consciousness of innovation, discernment, not-blind faith of authority and independent judgment), and excellent volitional quality.

Teachers should set up the correct education concept of physics creativity, including the following: firstly, protecting students' curiosity, relieving students' fear of faults, encouraging originality and diversity, encouraging fantasy and encouraging them to communicate more with creative persons; secondly, there are abundant factors for cultivating college students' creativity in physics.

As a science, physics knowledge is concerned with observation, experiment and thinking. Physics has a wide application in daily life and society. There are abundant scientific knowledge, ideology and methods in physics, which are a solid foundation for cultivating students' creativity. The content of physics methodology provides a beneficial methodological tool to students for their physics creation. Furthermore, students' learning of physics has the nature and value of creativity. Even though the physics knowledge that the students learn are achievements created by predecessors, they are at the position of discovery in the studying process when they are the learning subject. For themselves, studying of physics still possesses the property of discovery and re-discovery and it has the value of doing personnel discovery and creation. Therefore, in the teaching of professional courses of physics, teachers shall pay attention to construct a harmonious and democratic atmosphere, help students communicate at the best psychological states, ensure students in a comfortable mind, and promote their development of creativity [5].

### Overall cultivation of students' creative thinking ability of physics

Creative thinking is a thinking activity when all the intelligence and physical strength are in a highly motivated state, which is a normal physical and psychological activity. The traditional teaching of physics attaches importance to the cultivation of students' logical thinking, which is emphasized deductive inference and strict logicity of formal reasoning over

illogical thinking. In fact, creative thinking is a dialectical unity of logical and illogical thinking, which is an important component of creative thinking. Illogical thinking mainly includes imaginal thinking, intuitive thinking, inspiration thinking, and science and aesthetic ideology. Therefore, in the teaching process of professional courses of physics, while the cultivation of students' logical thinking is being paid attention, teachers shall also attach importance to the cultivation of students' illogical thinking.

#### **Cultivation of imaginal thinking**

Imaginal thinking is a form of thinking, which reveals the essence and objective law of the objective object based on perceptual knowledge and through image, association and imagination. Physics image mostly comes from practice. The ideal models in physics (such as  $\alpha$ -particle scattering model by Rutherford, ideal gas model, Carnot cycle, etc.) are all creative new images formed through physicists' processing. Through the teaching of professional courses, the students shall form correct physics image and the custom of thinking by applying physics images. For example, they shall be accustomed to transfer the life image to physics image, master the skill of visualizing abstract physics problems.

#### **Cultivation of divergent thinking**

Divergent thinking is a prominent feature of creative thinking. In physics teaching, teachers shall value variable teaching, cultivate the college students' ability of divergent thinking and avoid the negative effect of single thinking mode on them. In the process of solving problems of physics, the analysis of physics process shall be valued, which allows the students to solve a physics problem from different views and by different methods and by forms like one problem with more solutions, one question with variants, etc. So that students can be free from the single thinking mode. In addition, teachers can select and edit some exercises of procedure, of practical application and of implied and unknown physics quantity. When the thinking is diverged in a good way, more things can be selected and the selected results would be novel and with creativity. In the meantime, teacher shall pay attention to the cultivation of students' convergent thinking, which mainly aims to cultivate the students to analyze, compare, synthesize and select from the various answers and assumptions provided by divergent thinking. Students shall select a best answer and achieve the creative result by convergent thinking.

#### **Cultivation of intuitive thinking**

Intuition and inspiration are the immediate apprehension of an object by the mind without the intervention of any reasoning process [6]. They are the focused breakthrough that the creative subject thinks every normally accumulated clue of the solving the problem. They are sudden understanding of the creative subject's consciousness and subconscious. Intuition and inspiration can help students to originate at an unconscious level and, aided by insight, suddenly illuminates the mind [7]. In the teaching process, teachers can introduce the examples of physicists' applying intuitive thinking, such as leading to the displacement current of Maxwell equations, the proposal of Planck's quantum hypothesis and Einstein proposed light quantum (photon), which are all results of intuitive thinking. Teachers shall encourage and inspire the students to dare to conjecture, imagine and ask. They can guide the students to put forward intuitive conjecture by applying daily life experience and prior knowledge; by using analogical association and analogical reasoning, they can guide students to conduct intuitive thinking; in the solving and testing procedure of physics problems, guide the students to apply intuitive thinking;

encourage the students to participate in various extracurricular scientific activities, read widely and from a wide knowledge structure of physics taking physics as the center.

#### **Cultivation of physics aesthetic thinking**

Physics aesthetic thinking stands in the high level of physics creativity. The beauty of physics mainly manifests as the concision, symmetry, harmony and uniformity in the variety of a physics world. The scientific beauty in physics is not only performing in the theories of physics, but also in the creating process of physicists. The ideal models of physics are simple and clear, which reflects the physicists' constant pursuit to concision aesthetics of science. In physics, motion and rest, particles and antiparticles, matter and antimatter and so on all show the beauty of symmetry in physics. The conservation and conversion law of energy explain the unity between force, heat, electromagnetism, light, chemistry and various natural phenomena. In the teaching process of physics professional courses, the inner beauty of physics shall be fully explored. Through physics phenomenon, conception, laws, experiment, method, image, history and so on, teachers can reveal the beauty of concision, symmetry, harmony and uniformity in a variety of the physics world. To train the students to have the ability of creating beauty in the teaching process, firstly, the students shall master the aesthetic rule, like symmetry, concordance, conciseness, uniformity in variety, conservatives, etc. and apply them flexibly to solve physics problems. Secondly, in the practices (like observation, experiment, solving problems, etc.), the students shall have a thorough understanding of the performance, structure, characteristic and form of the material that the creation of beauty is relied on.

#### **Implementing various experiments and scientific practices**

The base point of physics creativity is at observation and the creation starts from observation. Sharp and fine observation is the premise of invention and creation. Observation and experiment are helpful to stimulate students' desire for knowledge and curiosity, and they encourage students to think independently, explore actively and discover problems. In the teaching process of professional courses, teachers shall let the students conduct meticulous observation at the physics images, charts and experimental phenomenon and observe and explore the physics phenomenon in the life and natural world deeply and conscientiously, and train their selectivity, veracity, sensitivity, profundity and comprehensiveness at physics observation.

Scientific practice is an activity that has a close relation with the development of students' creativity. Physics scientific practices develop a new channel for college students to achieve scientific knowledge and a chance for them to contact with the nature and actual production extensively. The practice can be conducted according to the characteristic and specialty of each student, so that students can have the site and the chance to do a manageable scientific exploration and creation. Form the practices, students can know the development trend of modern technology in time, broaden their horizon, awake their desire of exploration and cultivate their self-study ability, scientific inquiry ability, operational capacity, organizing ability and creativity. There are many kinds of physics, scientific practices, such as experimental investigation, scientific paper writing, patent application, etc.; interest group of various contents: making model planes, self-made training and learning aid, bicycle mending, maintenance of electronic products and such practical operations; activities of problem research and scientific inquiry, like research of nano-materials' function, research of Foucault pendulum, etc.; various science and technology lectures, competition, exhibition and festival activities.

### **Cultivating students to master the creative principle and creative technique of physics**

Physics education theory and teaching practice both prove that by creative technique penetrating in professional teaching content or lecturing creative technique in professional lectures to teach students the creative principle and creative techniques that the creationists summarized has a more effective result to develop physics creativity of students. The creative techniques of physics are mainly as follows:

#### **Brainstorming method**

Brainstorming method is also called intellectual stimulation method, which is an effective creative technique by mutual encouragement with swarm intelligence to produce the creative idea of the creation. Brainstorming is generally in the form of a kind of special topic meeting, and it makes every participant speak freely, inspire each other, mutually and encourage each other, so as to set up a chain reaction to the creative idea [8]. The rule of it is free, unrestrained, no critique, dominating by quantity and mutual encouragement. Studies show that group's free contact force increases by 65% - 93% than when they alone [9]. As the Copenhagen school represented by Bohr, they advocate a kind of unique, strong, honest, enthusiastic, equal and free academic atmosphere to discuss and cooperate with each other closely. They created the basic theory of quantum mechanics and gave a reasonable explanation to it, so that quantum mechanics get many new applications. The members won the Nobel Prize for many times. This is a successful example of the intellectual stimulation method.

#### **Association method**

Association refers to the psychological process of perceiving or remembering something so that thinking of other related things. Association can overcome the gap between the two concepts and link them. Association can be divided in the process of conception, association and conception, three stages. The common associations are, a similar association (trolleys and carts and others examples of people putting forth), comparative association (gravity and repulsion and electric magnetic and magnetic electric), correlated association, free association, etc.

#### **Analogy techniques**

Analogy is a thinking of being inspired and forming an analogy according to the similarity of the object. Analogy according to the similarity of between things is an important way to solve problems. An analogy can be divided into from analogy, structural analogy, functional analogy, cause and effect analogy, etc. For example, German manufacturers were inspired from the shark skin and developed energy-saving aircraft with shark skin imitated fuselage; a Swiss, Gyorgyi saw the phenomenon of a cocklebur fruit sticking on clothes and invented the widely-used adhesion tape of hooking and pulling by analogy.

#### **Thinking of transplant**

Transplantation is to apply and penetrate the principle, technique and methods of one field into other fields to transform or create new things. The main ways of transplantation are: (a) transplantation of principle. For example, an American inventor, Bell transplanted technical principle, "vibrating reed transmits sound and then people of vocal cord vibrates to transmit voice",

and designed a telephone, and in 1878 he acquired telephone patent right in the United States. Infrared radiation principle out physics field is transplanted into the medical field, where occurred infrared scanning diagnosis. When it was transplanted and applied in military field, there appeared infrared scanning, infrared guidance, etc. (b) Transplantation of methods. Such as mathematical, statistical method can be introduced to thermal field and experimental method can be introduced into the education field. (c) Transplantation of functions. Such as, the radiation of the radiation rays is harmful to the human body, but it can improve crop varieties and breed new varieties after a certain dose of radiation on crop seed.

#### **Conclusion**

Physics contains a wealth of creative education factors. Physics creativity is a comprehensive ability that developed from observation, experiment and creative thinking ability and other bases. It demonstrates the comprehensive quality of the student. Students with creativity have a strong thirst for knowledge, good thinking quality, independent characteristic. The cultivation of creativity for college physics students shall be rooted in each link of teaching of professional courses, such as theoretical knowledge learning, experimental operation, solution of physics problems, scientific practices and other teaching links. This is conducive to the promotion of teaching quality in professional courses and to the improvement of the cultivation quality of physics talents.

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