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Short Communication

Exploration on the Training Path of Scientific Research Ability and Quality of Undergraduates Majoring in Applied Physics

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Abstract. Different from the traditional physics major, the applied physics major focuses on cultivating students' ability to solve natural science and engineering technology problems using physical principles and methods. To this end, relevant teachers in the applied physics major were organized to spontaneously carry out undergraduate scientific research ability and quality training activities, establish a team of academic tutors, form a method for student selection, team formation and management, and carry out supplementary knowledge teaching for specific research projects, accumulating experience in the use of experimental instruments and equipment, data analysis, and technical paper writing skills training. The results show that, on the basis of fully exploring the interest and ability of undergraduates, appropriate guidance and solid training can stimulate students' interest in scientific research and greatly improve their scientific and technological innovation ability.

Keywords: Applied Physics, undergraduate, scientific research ability, scientific and technological innovation.

INTRODUCTION

The undergraduate major of applied physics is one of the important components of physics majors. The core of its talent training is to cultivate students' ability to solve natural science and engineering technology problems by applying physics principles and methods on the basis of mastering solid theoretical knowledge of physics and experimental skills (Jagero, 2013; Tambwe, 2017; Martin, 2017; Wong, 2012). Therefore, it can be classified as an applied or engineering undergraduate major. The major is characterized by rich content and comprehensiveness, covering multiple disciplines, such as functional materials, electronic information, engineering physics, energy physics, etc. (Mingjun, 2015; Yi, 2021). It is precisely because of the comprehensive nature of this major and the emphasis on theoretical knowledge and practical ability training that many universities have opened this major (Ilomo, 2016; Hang, 2020; Wenjuan, 2019). In combination with the existing faculty of this major, the researcher and relevant teachers spontaneously organized undergraduate scientific research ability training and quality training in the applied physics major, and tried to attach equal importance to classroom learning and scientific research practice, which fully explored the seed players suitable for scientific research, and summarized a set of experience methods, aiming to provide reference for other similar universities and professional teaching reform and development (Li, 2016).

The Development Background of Applied Physics in Local University

Local university have distinctive disciplinary characteristics

Most of the applied physics majors in Chinese colleges and universities are given a specific training direction based on the discipline advantages or industry

Table 1. Statistics of teachers and students in scientific research ability and quality training of undergraduate students of applied physics from 2019 to 2022.

Teacher research field	Number of teachers involved	Number of national level projects	Number of students involved
Photoelectric detection materials and devices	3	2	6
Organic/inorganic light-emitting materials and devices	2	2	4
Lithium battery materials	1	1	2
Supercapacitor	1	0	2
Gas/pressure sensor components and systems	1	0	2
Material Design and Simulation	2	2	4

background of the school, while meeting the basic requirements of physics, which is most obvious in local undergraduate colleges and industry colleges. For example, combine physics with geology, architecture, communication, biology, metallurgy, ocean, meteorology, materials, energy, rail transit and other industries, and focus on cultivating students' ability to solve engineering and technical problems in specific industries using physical principles and methods, as well as the ability to carry out cutting-edge technology research. At present, the integration of science and engineering and interdisciplinary development is one of the remarkable features of high-tech development. Professionals with deep physical knowledge and skills background can provide scientific and systematic decision-making reference when participating in professional scientific research, engineering technology development, project technology management, intellectual property protection, etc., while the training objectives and contents, teaching forms and contents of applied physics are consistent with the above requirements.

Significant contradiction between supply and demand of teachers and students in local colleges

With the return of talents at all levels in recent years, local undergraduate colleges have attracted a large number of young academic talents with rich research experience. However, due to the historical reasons of running schools, local undergraduate colleges and universities have fewer authorized disciplines for master's and doctor's degrees, and insufficient student indicators are allocated each year. As a result, teachers with research experience or topics cannot obtain enough master's and doctor's students, which affects the development of teachers' subject research to a certain extent. However, the applied physics specialty has the characteristics of covering a wide range of disciplines and being suitable for interdisciplinary. In the absence of recruitment indicators for masters and doctors, students who are interested, love to study, have a good foundation and self-study ability can be selected from senior undergraduate students to participate in teachers' research projects, scientific research ability training and scientific practice quality training that can be conducted under the guidance of teachers. As a result, it can not only partially alleviate the contradiction of the lack of student indicators, but also find out undergraduates with scientific research ability and quality, and provide high-quality students for graduate enrolment units.

Establishment and Management of Undergraduate Scientific Research Competence Training Personnel

Establishment of Academic Tutors

A professional team of academic tutors is the primary condition for the cultivation of undergraduate scientific research ability and quality. Following the principle of voluntariness, this study have established an information base of academic tutors in the college to give a brief introduction to teachers and research directions, and have face-to-face interaction with students of the major by means of lectures. Each tutor puts forward requirements for students according to their needs. The research directions of teachers facing this major mainly include photoelectric detection materials and devices, organic/inorganic light-emitting materials and devices, lithium battery materials, supercapacitors, gas/pressure sensor devices and systems, material design and simulation, etc. There are more than 10 teachers, and most of them are young teachers with doctoral degrees, as shown in Table 1. In order to effectively implement the cultivation of undergraduate scientific research ability and quality, and ensure its high-quality implementation, the study follows the principle of "fewer but better", and each tutor will guide not more than 6 undergraduate students annually. That is to say, in order to ensure the gradient of students, the tutor can guide up to two students in each grade from sophomore to senior. Therefore, the number of tutors directly determines the number of students who can participate. For this major, the number of teachers will increase from 2 in 2019 to 10 in 2022, realizing the scale of 30 students.

Student team formation

Students who meet the requirements of interest, love to study, and have good self-study ability are the key attraction of undergraduate research ability quality training. Adhering to the concept of "interest is the prerequisite for continuous investment in scientific research",

the study selected appropriate students in the first semester of sophomore year to carry out early literature reading, supplementary teaching of basic professional knowledge, regular team exchange and discussion and other activities. Some students gradually gave up voluntarily, while the students who always insisted on participating and staying also gradually showed a strong interest in research direction. The study also look forward to the specific research tasks to be carried out. In this process, the instructor can also fully understand the advantages and disadvantages of students, and conduct targeted guidance and supervision training. According to experience, the number of students left voluntarily after this round is 1-2 for each tutor. As students in senior and middle grades are distributed in the student team, a sustainable "mentoring" model has been formed.

Student team management

The "three self" ability of "voluntariness, self-control and self-management" is one of the objectives of undergraduate scientific research ability quality training. First of all, for all the students involved, each instructor will organize students to hold a large group meeting every month in turn. Each student will report and display the recent work progress, difficult problems, next step plans, etc., and the instructor will give instructions one by one. Through the group meeting, the participating students can see the advantages and disadvantages of other students, so as to think about their own work and shortcomings, and form a contrast, competition and supervision among students. Secondly, for a single tutor team, a group meeting will be held every week or half a month to report the progress of the work arranged. The tutor will guide and supervise the students according to the specific work and their own situation, and answer the students' questions on the spot. Moreover, there are graduate students, senior and middle grade undergraduates in the student team. The tutor intentionally cultivates the team's self-management ability in the process of "mentoring". It should be emphasized that undergraduates' participation in scientific research activities is mainly driven by interest and willingness, and they use their spare time and vacation time. Therefore, in the management process, special attention should be paid to remind students to allocate time and energy. Overweight or mechanized scientific research tasks may gradually cause students to lose interest and motivation.

Implementation of Undergraduate Scientific Research Competence Training Process

Supplementary teaching of basic knowledge for specific projects

The basic knowledge teaching process aimed at researching specific projects can enable students to effectively understand and master the logical relationship between physical principles, models and research tasks to be carried out in a short time, and initially establish the physical framework of the research object. The general practice is to arrange the corresponding book chapters, scientific and technological documents for specific projects, complete the reading within 1 month, sort out all the incomprehensible or doubtful contents, and then focus on these issues in the supplementary teaching process in combination with the needs of the project. According to the students' self-study ability, they generally need to finish reading at least 4 books and 20 articles in the first semester of sophomore year. The teachers' supplementary teaching time is generally 10-20 class hours. Taking the research of semiconductor photodetector project as an example, since the major was offering Solid State Physics in the first semester of sophomore year, after the chapter of "Energy Band Theory" was completed according to the normal teaching schedule, the participating students will be assigned self-study tasks in the chapters of "Electronic State in Semiconductors", "Conductivity Type of Semiconductors", "Conductivity" and "Unbalanced Carrier" of Semiconductor Physics. The supplementary teaching will be carried out about one month later, and relevant knowledge points will be taught according to the needs of the project. According to the schedule, arrange relevant chapters of Semiconductor and Device Physics and Technology, Thin Film Physics, Test and Analysis Technology and other books for self-study and supplementary teaching, are shown in Figure 1. Such an intensive self-study task requires students to complete it within 4 to 6 months, which can not only test their self-study ability, but also screen out students who are really persistent and interested, so as to lay a solid foundation for later experimental work.

Training on instrument and equipment use skills

Skillful use of relevant experimental instruments and equipment is a necessary skill for students to carry out experimental research projects. Taking the research of semiconductor photodetector project as an example, it mainly includes preparation equipment, structure and morphology testing equipment, spectrum testing equipment, electrical parameter testing equipment and device functionality testing equipment. The instrument and equipment skills training is mainly divided into two parts. One is the public testing and analysis equipment. According to the person in charge of the instrument, regular training is conducted for all teachers and students of the hospital every semester. The other is the special equipment of the research group trained by the instructor. The application skills of instruments and equipment are mainly carried out in the second semester of sophomore year, such as magnetron sputtering instrument, vacuum thermal evaporation, spin coating instrument, plasma cleaning machine and other major preparation equipment,

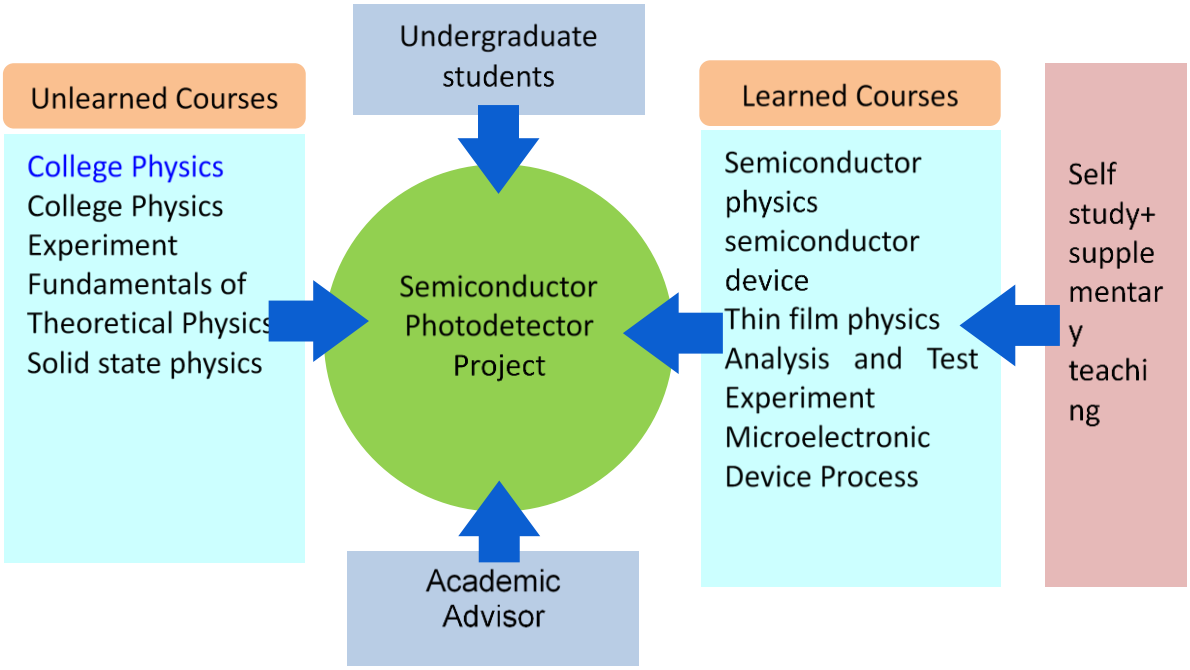

Figure 1. Teaching Course Arrangement of Semiconductor Photodetector Project Implementation.

metallographic microscope, X-ray diffractometer, atomic force microscope and other structural morphology analysis equipment, ultraviolet visible spectrometer, infrared spectrometer, fluorescence spectrometer and other spectral analysis equipment, as well as semiconductor parameter analyzer and other electrical and device function testing equipment.

Training on data analysis and scientific paper writing

Experimental data analysis and scientific and technological copy writing are one of the important ways to express research results. At this stage, the main training is to draw, analyze and process the data and images obtained by various testing instruments, and make charts that meet the requirements of scientific papers. Software for instrument data analysis includes Jade (X-ray diffractometer data), Gwyddion (atomic force microscope images and data), XPSpeak (peak fitting of X-ray photoelectron spectroscopy data), and Gatan Digital Micrograph (transmission electron microscope images and data); Original, SigmaPlot, Matlab and other software are involved in data mapping; Tools involved in modeling and simulation include CrystalMaker (crystal structure modeling), AutoCAD (engineering drawing), Materials Studio (material simulation), ANSYS (multi physical field simulation), etc. For the writing of science and technology theory, select articles related to research projects for intensive reading, and explain the paper framework, writing ideas, analysis methods and views.

CONCLUSION

Early implementation has achieved significant results

After two years of training and practice, the abilities of the students involved in self-study, literature reading, experiment, scientific and technological paper writing, communication and expression, team cooperation, etc. have been significantly improved, and some students have become good helpers of teachers. The participating students can basically write and publish scientific papers and patents before graduation. Graduated and employed students can directly participate in relevant research and development (R&D) and management work in their counterparts, which is highly recognized by enterprises. Some students even directly obtain jobs in foreign capital or joint ventures. The students who continue their further studies have been admitted as master's students in key universities and national scientific research institutions, and their abilities and qualities have also been highly recognized by their tutors. Some students have also directly won full prize doctoral positions in foreign universities. This shows that fully exploring the interest and ability of undergraduates, combined with appropriate guidance and solid training, can stimulate students' scientific and technological innovation ability at the undergraduate stage.

Difficulties and deficiencies still exist

At present, the undergraduate scientific research ability an

and quality training activities carried out in this major are mainly based on the principle of voluntariness of both teachers and students, and the undergraduate students participate as auxiliary personnel when the postgraduate indicators are relatively scarce, which is difficult to exist for a long time and cover a large area without system guarantee. The financial, material and human resources of local undergraduate colleges are limited, so it is difficult to ensure that all students participating in the program can obtain high-quality output. The main energy of undergraduate students is still to study the established courses. Credits are required to complete the degree, and some students are not mature enough, which puts forward higher requirements for students' time management, energy distribution, self-improvement and other abilities.

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REFERENCE

Jagero N (2013). Education production function and quality of education in day secondary schools in Kenya. Austr. J. Bus. Manage. Res., 2(12):28-33.

Tambwe MA (2017). Challenges facing implementation of competency based education and training (CBET) system in Tanzanian technical institutions. Educ. Res. J., 7(11):277-283.

Martin EN (2017). Correlation between the availability of resources and efficiency of the school system within the framework of the implementation of competency-based teaching approaches in Cameroon. J. Educ. Pract., 8(2):82-92.

Wong C (2012). Enhancing students understanding of values in practice: integrating theory & practice in SoTL. In: Abstracts from the International Society for the Scholarship of Teaching & Learning Conference. H24:159-160.

Mingjun Q (2015). Exploration and practice of training top innovative talents in provincial colleges and universities - Taking Chucai College of Hubei University as an example. Contemp. Cont. Edu., 33(6):76-78+82.

Yi G (2021). Research and practice on the training program of top talents in applied physics major - A case study of applied physics major in Harbin University of Technology. Heilongjiang Education. Res. Eval. Higher Edu., 9: 68-69.

Ilomo O, Mlavi B (2016). The availability of teaching and learning facilities and their effects on academic performance in ward secondary schools in Muheza – Tanzania. Int. J. Edu. Res., 5(6):571-582.

Hang W (2020). Research on the curriculum construction of applied physics in application-oriented universities. Physics Bulletin. 10:16-18+22.

Wenjuan W (2019). Application and investigation of engineering professional certification in applied physics. Education and Teaching Forum. 40: 156-157.

Li L (2016). Research and practice on the talent training mode of applied physics under the background of engineering. Science and Technology Innovation Herald. 13(25):157-158.