

Progress in Education of Optical Engineering in China

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ABSTRACT

Since the establishment of first speciality of optical instrumentation in Zhejiang University and Beijing Institute of Technology in the early 1950's, the great progress in optical engineering education has been made in China. At present, more than ten universities and colleges offer undergraduate and graduate programs in optical engineering. Summary information of academic institutions of higher engineering education that offer programs in optical engineering is given in this paper.

With the execution of the open-door policy and of the reform in economic, scientific and technological sectors, optical engineering as like others is now undergoing a reform, exploration and evolution in China. This paper presents the change, challenge and opportunity the institutions are facing. Taking Optical Engineering Department at Zhejiang University as an example, the activities and measures adopted are described. Revised undergraduate and graduate programs are also illustrated in this paper.

1. A BRIEF INTRODUCTION

The field of applied optics began a rapid growth period 30 more years ago. To meet the need and demand for educated and trained optical engineers, the first speciality of optical instrumentation in China was established in Zhejiang University and Beijing Institute of Technology in the early 1950's. They have grown to become the largest centers in China for teaching and research in optical engineering. As applied optics become more pervasive and is finding new applications almost every day which ranged from military to industrial and consumer markets. A number of universities and institutes have established undergraduate and graduate programs in applied optics and optical engineering. Table 1. shows summary information of academic institutions of higher engineering education in China that offer programs in optical engineering. In addition, some comprehensive universities, such as Nankai University and Fu Dan University etc., offer undergraduate and graduate programs in optical science, mainly in Physics Departments. Research institutes of Academia Sinica, such as

Table 1. Summary Information of Academic Institutions

Institution	Speciality	The year of Inception	Enrollment Per Year		
			Under-	MS	Ph. D
Zhejiang University Dept. of Optical Engineering Director, Tang Jinfa	Optical Instrumentation Applied Optics	1952	100	28~30	5~6
Beijing Institute of Technology Dept. of Optical Engineering Director, Yu Xin	Optical Instrumentation Optical System Design and Testing Opto-electronical Technology	1954	90	28~30	5~6
Tianjin University Dept. of Precision Instrumentation Eng. Director, Zhang Guosiang	Optical Instrumentation Photoelectronic Technology	1958	~70	~20	2~4
Wuhan Technical University of Surveying and Mapping, Dept. of Optical Instruments Director, Chen Xiaodong	Optical Instrumentation	1958	60	3~6	
Changchun College of Optics and Fine Mechanics Director, Mao Yingtai	Optical Instrumentation Optical Fabrication and Testing	1958	85	3~5	
Tsinghua University Dept. of Precision Instruments and Mechanology Director, Zhou Zhaoying	Optical Instrumentation	1959	40	15~20	3~4
East China Institute of Technology Dept. of Electro-Optical Technology Director, Chen Jinbang	Optical Instrumentation	1960	30	6	2
Beijing Polytechnic University, Dept. of Mechanical Engineering Director, Yin Deyi	Optical Instrumentation	1960	30	1	
Shanghai Institute of Mechanical Eng. Subinstitute of Meters and Instruments Director, Zhou Pengfei	Optical Instrumentation Optoelectronics	1964	70	7	
Xian Institute of Technology, Instrument Engineering Department Director, Liu Muxing	Optical Technology and Measurement	1965	50		
Huazhong University of Science and Tech. Dept. of Optical Engineering Director, Lu Xinde	Optical Instrumentation Optoelectronic Technology	1970	90	20	1~2

Changchun Institute of Optics and Fine Mechanics, Shanghai Institute of Optics and Fine Mechanics, Shanghai Institute of Technical Physics etc., have also established MS and PhD programs in optical science and engineering. We restrict ourself to describe programs in optical engineering offered by academic institutions of higher engineering education in this paper. Since "Optics is a light work", it attracted tremendous students to enter in this field. Since 1956, more than 7000 undergraduate degrees, 500 MS degrees and 50 PhD degrees have been awarded. As a whole, the curricula leading to these degrees provided students with a firm foundation in optical engineering and applied science and prepare graduates for immediate practice of the profession as well as advanced studies. Graduates were allocated to most of large and medium factories of optical or optics related industries as well as research institutes of Academia Sinica and of various ministries of industry.

2. CHANGE, CHALLENGE AND OPPORTUNITY

In the recent years, with the execution of the open-door policy and of the reform in economic, scientific and technological sectors, a number of small business, private and township enterprises, especially in the coastal areas, have been established, resulting in co-existence of different ownerships with public ownership as the principal part, co-existence of many ways of distribution with the distribution according to work as the main part. The economic structure is developing towards multiplicity, therefore the need of trained personnel is also multi-leveled and multi-styled. On the other hand, China is currently in initial stage of socialist development, the central task is to develop the productive forces of the society and to improve the people's living standard. A great emphasis has been put on the basic industries, such as energy, transportation, communication and materials etc. The need and demand for educated optical engineers slumped for some time. A certain amount of graduates majoring in optical engineering were engaged in non-optics related industries. As a consequence, yearly enrollment of undergraduate students majoring in optical engineering are reduced recently. It is well known that higher education must serve economic development and economic development must rely on education. The goal of higher education is to train specialized personnel so as to satisfy the needs of economic boosting and development of science and technology. However, the needs of society can be divided into those of short-term and long-term nature. Industries measure their profit in months, while we educationalists measure successes in years. At the realities of the day, the need for trained personnel in traditional engineering, such as mechanical engineering, electrical engineering, civil engineering etc., but not optical engineering, is greatly increased. However, today, 30 years after the invention of lasers, optics has not been viewed as only a branch of physics. Modern optics and optical technology have stretched to optoelectronics, optical information processing and optical computing. It is likely that optical technology may well become the technology of the 21st century. Therefore it is necessary to properly handle the relation between the current and long-term needs concerning the training of personnel, and moreover

considering the delaying effect of its own function , arrangements should be made ahead of time in light of the tendency of the development of economy , science and technology. Shortage of funding is another problem which more or less puzzled most of academic institutions . Since China is still a developing country whose economy is quite backward compared with those of advanced countries .Although salaries for all faculty members and staffs , stipends for all graduate students , and necessary expenses for teaching practice and construction of apartment buildings come steadily from the government , the budget is still limited . The cost of capital equipment today is significantly higher than ever before .Therefore university and departments have to find extral sources to carry out high level research , if you want to maintain a first rate university , a first-rate department. This creates enormous pressure on our academic institutions. All these factors mentioned present a great challenge and can be viewed as an opportunity.

Every academic institutions are taking measures to deal with the changing situation . Mainly adjustment of structure and layers of undergraduate and graduate programs , broadening of scope of specialities , close cooperation with industries as well as introduction of competition mechnism in education are performed . To illustrate in some detail we would like to take the Department of Optical Engineering at Zhejiang University as an example . The University is one of the key universities directly under the State Education Commission . As other key universities, it becomes two centers of teaching and research. It is equally important to train undergraduate students and doctorate and master degree graduate students in this University . The optical instrumentation speciality was established in 1952 . It has become Optical Engineering Department since 1960 ,with outstanding faculty and researchers , facilities and curricula that cover the broad field of applied optics and optical engineering. The Department is one of six academic institutions which have been approved to train and to award doctorte degrees on optical instrumentation . Presently undergraduate and graduate enrollments total approximately four hundred and one hundred , respectively. There are around one hundred faculty members including nine full professors and forty more associate professors. Although this is a research-oriented department , it offers thirty more undergraduate and graduate level courses and six laboratory courses, which are structured to include three block courses ,involved in optics , precision mechnics, as well as electronics and computers . Students receive thorough grounding in the fundamentals of engineering and in their primary specializations from outstanding faculty members and good facilities. This department has recently undertaken three-year \$ 1.2 million U.S. expansion and renovation program , adding state-of-the-art facilities to meet the complex requirements of the future.

In the recent years , to deal with the problems mentioned in the previous section , the following activities and measures have been taken,

- The undergraduate and graduate programs have been intensively studied and revised to broaden the scope of the spciality and discipline. The emphasis has been put on the training in fundamentals of technical science and engineering as well as in comprehensive ability to

resolve practical problems in engineering . The programs will be described in some detail in the following section.

● Two research institutes of Modern Optical Instrumentation and Optoelectronic Technology have been established with the purposes of training doctorate and master degree students, especially in supervision of their thesis and dissertation work ; of promoting cooperation with industrial world and technology transfer to major corporations , speeding up the process of transition from research achievements in laboratories to production forces. This also means there is more pressure on individual faculties to have more funded research , faculty are judged partly on their ability to obtain research funding . The positive effect is obvious that the research funds of the Department were greatly increased from around 800 thousand Chinese yen in 1987 to more than 2 million in 1990 .The expansion of cooperation of academic institutions with scientific research and production units becomes a common tendency , and is demanded by the development of higher engineering education itself as well. This is the eventual result of the development of modern economy, science and technology and education , and it is by no means a casual occurrence.

● First rate universities and departments should meet not only short-term goals, but also long-term needs for trained engineers . The faculty members are encouraged by favoured policies to apply for contracts and grants from the National Natural Science Foundation and the State Commission of Science and Technology to carry out basic-oriented research and high-tech research. The rapid pace of change in applied optics makes it important that faculty members stay at the forefronts of their fields , and that they understand how these fields are evolving . If they do not stay at the forefront , they will not be in a position to lead the change in curriculum that will be needed. Activity in research is the principal mechanism for keeping faculty at the forefront of technology. The faculty members have increased substantially their involvement with research. In addition around one third of the faculty members in this department have early or late taken sabbatic leave to go abroad working with foreign experts for a period of one to two years . It is helpful to absorb new ideas, to refresh our knowledge and to develop and strengthen the international exchange and cooperation .It is obvious that this activity is continuing. It is equally important (if not even more)to recruit promising young doctors trained in China and abroad into the faculty. The Department 's future is , in some extent , determined by them.

● A further step is going to merge the Optical Engineering Department with Scientific Instrumentation Department . It is becoming the Department of Optical & Scientific Instrumentation Engineering . Considering that optics is truly interdisciplinary . it might benefit teaching and research work and competition with counterparts.

3. Undergraduate program

3.1 Strengthening Fundamental Courses

In the past , the speciality is over narrow resulting in a contradiction between education

and employment . It is unable to meet the needs for enhancing adaptability to society. And also because of the rapid development of science and technology, the time for scientific knowledge to be outdated is shortened on the one hand , and the time for the achievements of scientific research to be used in new technology, new products and new industries is also shortened on the other . Technical personnets should continuously renew their knowledge. What they learned in university would never be enough for their professional career . Only those who master the long-lasting basic knowledge will be able to ease their knowledge tranfer in the changing world . It is therefore , an inexorable trend to strenghen the fundamental courses , including basic courses and courses of basic technology. The basic courses are listed in Table 2.

Table 2. Basic Courses

Mathematics,	Calculus,Ordinary Differential Equation Linear Algebra, Complex Variable Function Mathematical Physics Equation , Probability Theory	Credits, 19.5
Physics,	General Physics and Physics Laboratory	9.5
Microcomputer,	Computer Language and Programing , Digital Methods, Microcomputer and Its Applications	8.5
Optics,	Geometrical Optics,Physical Optics, Optical Testing Optics Laboratory	16
Chemistry,	Engineering Chemistry	4

Courses of basic technology (Table 3 and Table 4) have been set up according to electrical engineering-oriented and mechanical engineering -oriented modes, respecticely, for sudents selection .

Table 3.Courses of Basic Technolog for Electrical Engineering-Oriented Mode

Electronics,	Principles of Circuit , Circuits in Instruments, Analogical Electronics Technology, Digital Electronics Technology, Interfacing of Microcomputer, Opto-electrical technology,	Credits, 26
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Mechanics,	Engineering Drawing , Elements of Precision Mechnics, Introduction to opto-mechanics Design	11
Optics,	Principles of Lasers , Laser Technology	7

Table 4. Courses of Basic Technology for Mechanical Engineering-Oriented Mode

Electronics,	Principles of Circuit, Analogical Electronics Technology Digital Electronics Technology	Credits, 16
Mechanics,	Engineering Mechnics, Engineering Materiats , Engineering Drawing , Elements and Devices of Precision Mechanics , Precision Instruments, Introduction to Optical Instruments Design , Tolerance and Measuring Techniques	26.5
Optics,	Optical Lens Design, Fundamentals of Lasers	6

3.2 Traditional Specialized Courses Complemented by Courses in Modern Optical Technology

In addition of traditional specialized courses , such as Optical Fabrication and Testing , Photographic Instrumentation , Interferometers, Spectroscopic Instrumentation , Photometric and Colorometric Instrumentation etc., we also offer course of modern optical technology , such as Optical Holography , Fiber Optics and Optical Fiber Sensors, Detectors and Infrared Technique, Pattern Recognition and Digital Imagine Processing etc., for students selection . Students are also encouraged to minoring in other specialities, such as Computer Science , Industrial Process Control, Management etc. Recently almost one third of students take this way to pursue dual degree of bachelor. The purposes of all these measures are to make students' knowledge more wide and have relatively strong points in one field or in one discipline on solid basis of academic fundation , and to suit the needs of students' future careers.

3.3 Reinforcing Practice Engineering Training

The original goal of engineering education is to train engineers and technical personnels with both ability and integrity . So engineering training should no longer be carried out on the self-sealing campus, centering only around classrooms and experiments . Theoretical study should integrate with practice, combine with research and production work. Students must get in touch with and get to know the advanced industrial technology , choose their graduation projects and theses from the real world , and to acquire skills in engineering practice.

In the recent years , in addition of Spring term and Fall term , we set up a short Summer

term , when students are arranged to work on electronics technology experiments , or design practice in precision mechanics, or to practice in optics workshop and instruments workshop.

Pre-assignment and industry-university joint training Program has been established on trial . A certain amount of students after three years study are pre-assigned to optics related industry for a period of one year . At that period they are working as technical staffs and get in practical engineering training .After one year students come back the department to continue their course work and to carry out graduation projects . This program is sometimes simply called 3·1·1 joint program. It has brought fresh air to engineering education in universities, change the original state of regarding theories and research as superior to practice and application , enriched the students ' classroom experiences , and at the same time universities have gained strong support from the industrial circles.

4. MS AND PhD DEGREE PROGRAMS

MS and PhD degree programs have been established in China since 1978. MS students usually are required to finish course work of 35 credits , including 5 core courses. Thesis work for a period of one to one and half a year is unexceptional for all MS students . Up to now MS degree programs are dominant in graduate education in China. It is determined by the needs of the society , the development level of economy , science and technology. It should be noted that this situation is changing .More emphasis will be put on PhD degree programs in key universities and institutes .Further development of education in advanced degrees is expected in coming years.

Table 5. Courses for graduate students

Classification	Courses
Optics	Advanced Physical Optics , Optical Imaging Theory and Image Evaluation , Optical Systems Design , Optical and Computer Generated Holography, Thin Film Optics , Guided Wave Optics
Optoelectronics	Nonlinear Optics , Laser Spectroscopy, Fundamentals of Optical Information Transmission. Applied Technology of Lasers.
Instrumentation Engineering	Modern Spectroscopic Technology , Infrared Detectors and Systems , Optical Thin Film Technology , High-Speed Photographic Instrumentation
Electronics and Microcomputers	Weak Electrical Signal Detection , Intensive Electronic Experiments, Single-Board Computers and Applications , Advanced Experiments in Computer Interfacing , Digital Image Processing , Pattern Recognition

At present , the yearly enrollment of MS students and PhD students of this Department is around 28~30 and 5~6 , respectively. Every year we offer more than 20 courses which is listed in Table 5, for MS and PhD students' selection and also for graduate students from a few optics-related research institutes of Academia Sinica . The theses work is streeed on engineering and technological science . Students are directed to pay attention to high technology and use it to reform conventional optical engineering and technological science.

PhD students after finishing a MS program are required to complete course work of 15 credits . The emphasis is unexceptionally put on their dissertation work , which will take two and half a year .The subject of dissertation work has covered,

- optical instrumentation engineering involving the use of computers for optical system design , testing and image evaluation , coherent light technology and phase-shifting interferometry, scientific and industrial applications of colorimetry and spectrophotometry;

- optoelectronic technology and devices involving lasers , non-linear optics , optical fiber sensors , and optical information processing;

- applied spectroscopy and instrumentation including studies on Raman spectroscopy, Fourier spectroscopy, photoacoustic and photothermal deflection spectroscopy ;

- thin film optics and technology including studies on the relation between microstructure and macro-performance of optical thin films , computer-aided technique of thin film deposition and thin film characterization.

The University and the Department has performed a so-called "Sandwich Program " for Ph.D students. After finishing courses work at home university , some of promising Ph. D students are sent to abroad for experimental dissertation work for a period of around two years , then be back home to prepare manuscript of the dessertation and the final defense. A few students have been sent by the Department to France, Germany , United States , Japan and United Kingdom. By far the largest percentage of optical engineering graduates are employed in academic institutions , research institutes of the Academia Sinica and of the ministries of industries , and in commercially-oriented companies . They have won a high reputation for their training and skills in all areas of optical engineering .

5. CONCLUSION

The attention of development in education of optical engineering in China is being shifted to the quality improvement after a rapid increase in quantity. From the realities in Chian , the paper presented some activities and measures in areas such as strengthening the cooperation and exchange between academic institutions and industries and society , optimizing curriculum structure, combining teaching with scientific research and production to meet the needs of the society in terms of personnel training , research and technical survice. Further progress in optical engineering education can be expected by years efforts.