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# Training Model, Teacher Quality Requirements and Educational Implications for Mechanical Engineering Majors in German Applied Universities

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***Abstract:*** *In this paper, the professional curriculum system, training mode, teacher quality requirements and ability cultivation of mechanical engineering majors in Hamburg University of Applied Sciences in Germany were investigated. Its university running characteristics, the requirements of talent training and curriculum system on teachers' ability, the corresponding relationship between deepening the reform of engineering education and the training mechanism of professional teachers, and the quality requirements and ability training of professional teachers were analyzed. By comparing the teaching and teacher management system of mechanical engineering in University of Shanghai for Science and Technology, some suggestions were put forward in order to improve the quality of teaching and teachers' quality.*

***Keywords:*** *higher education; mechanical engineering; training mode; teacher quality*

## 1. Introduction

As one of the powerful mechanical industry countries in the world, Germany's strong manufacturing and innovation development capabilities have a lot to do with the advanced personnel training system of engineering professionals in German colleges and universities. The successful experience of German universities in the cultivation of engineering talents, which emphasizes practicality and aims to cultivate technical and applied talents, has a lot to learn from.

## 2. Professional curriculum

The reform of higher engineering education in Germany, which began in the 1970s, has built a number of applied science and technology universities for the purpose of training engineers in addition to the research universities. Under the new mode, the traditional Humboldt mode of integrating teaching and research is no longer applicable. The training of mechanical engineers began to reduce the professional focus, evaluate the learning outcomes (learning output) from the three aspects of knowledge, skills and ability, and take the cultivation of high-quality technical talents for enterprises as the positioning of colleges and universities, so as to meet the diversified needs of enterprises for the ability of mechanical professionals. Later, the German application-oriented university continuously translated the requirements of enterprises for the quality of mechanical professional teachers into specific teaching contents and training plans, requiring teachers to have practical engineering experience and enterprise employment experience, so as to ensure that teachers can update teaching contents and improve teaching methods from the perspective of engineering practice[1-2].

Hamburg University of Applied Sciences, founded in 1970, is a famous University of Applied Technology in Germany and ranks third in Germany in terms of scale, which is formed by the merger of four engineering and technology colleges and six higher technical schools. Different from comprehensive universities, which focus on the cultivation of students' academic research ability, students in universities of applied sciences pay attention to the cultivation of professional practice ability while learning basic theories. Experiments, internships and participation in related projects are an important part of the university learning stage. Students can be proficient in relevant operations through practice, and have accumulated a lot of experience in the university stage, so as to be ready for the future work of industry engineers.

Students majoring in mechanical engineering at the Hamburg University of Applied Sciences focus

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on basic knowledge in the first year of enrollment, focus on professional knowledge in the third to fifth semesters, and start to enter the enterprise internship in the sixth semester. After completing the internship in enterprises, students can choose the direction of further study. This major provides a total of five directions, namely metal and non-metal material technology, mechanical design and development, production technology, industrial management and technology management, and energy technology[3]. In the fourth academic year, 3 to 5 courses related to the selected professional direction will be selected for study. After completing the study, the final bachelor's thesis writing and thesis defense will be conducted.

The mechanical engineering students at University of Shanghai for Science and Technology mainly study basic theoretical knowledge and professional knowledge in the first and second academic years, and continue to study professional knowledge in depth in the third academic year. At the same time, they carry out mechanical design course design, and allow students to go out for internship. In the fourth academic year, students can independently choose their own employment-related courses to study. After completing the courses, they can write their graduation thesis and defend their graduation.

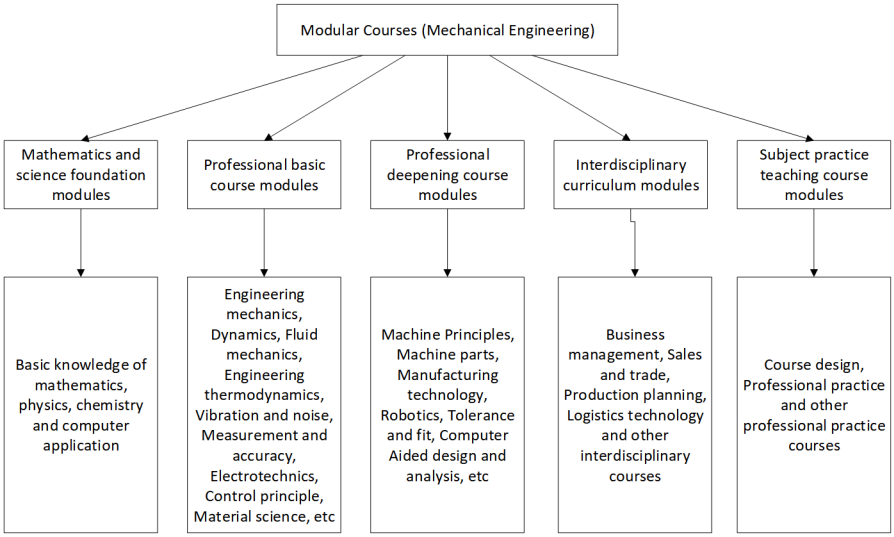


*Figure 1: Course module for mechanical Engineering at Hamburg University of Applied Sciences*

The foundation of mechanical engineering courses in German universities is extensive, and talents are cultivated through the establishment of different modular courses, as shown in Figure 1. Chemistry, thermodynamics, heat transfer, thermal engineering, materials science, fluid mechanics and other courses are compulsory courses, and most professional teachers come from enterprises, can achieve the combination of basic courses teaching and professional knowledge. The training program for mechanical engineering majors in German universities emphasizes the education of scientific and technological foundations and engineering application abilities education. The rich content of enterprise practice and the integration of theory with practice are the characteristics of German engineering education. Teaching methods such as lectures, exercises, thematic discussions, internships, project work, course projects, graduation projects and other teaching forms require teachers to have strong practical engineering knowledge and skills[4-6].

Figure 2 shows the course modules of the Mechanical Engineering major at University of Shanghai for Science and Technology, which have a more detailed classification and a wider range of coverage. This is because a considerable number of graduating students in domestic colleges and universities choose to continue their studies, and basic courses related to graduate exams account for a considerable proportion of teaching. Due to the wide range of employment opportunities in the field of mechanical engineering, some professional expansion and elective courses have been offered to enhance students' adaptability to different industries and enterprises. In addition, a large amount of general education is also an indispensable part of the curriculum modules in domestic universities. Comparing the mechanical engineering courses in universities in Germany and China, the characteristic of Germany is that there are fewer courses and more class hours, with a general 80 class hour professional course. This can be achieved through various forms such as group discussions, laboratory classes, and company visits and other forms; The characteristic of China is that there are many courses with wide coverage, but few class hours, and the theoretical depth and practicality of teaching core professional courses are relatively insufficient.

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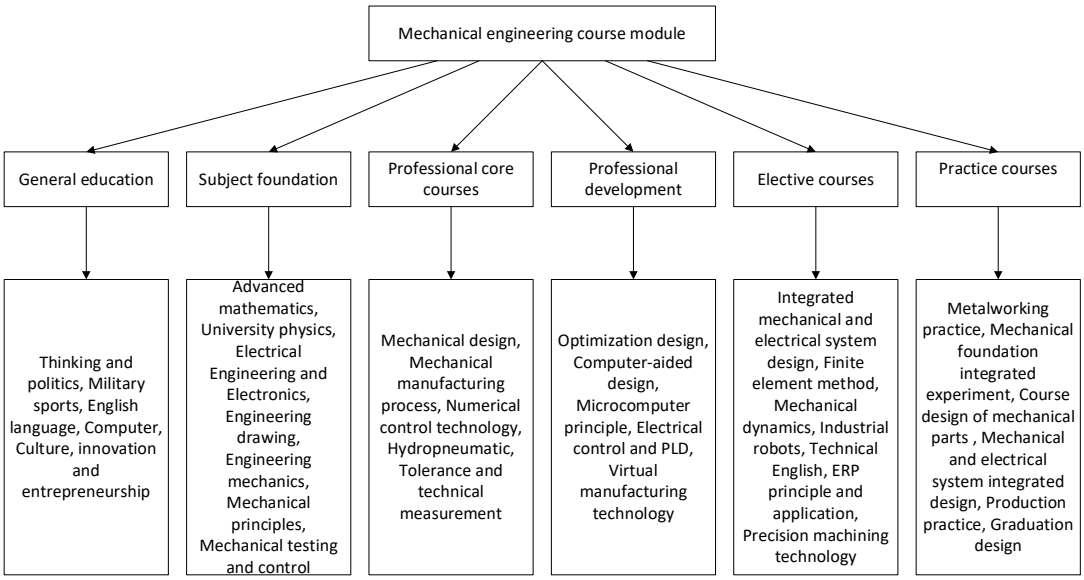


*Figure 2: Undergraduate course module for Mechanical Engineering at University of Shanghai for Science and Technology*

Table 1 shows a comparison of the course structure and hours for mechanical engineering students between Hamburg University of Applied Sciences and Shanghai University of Science and Technology. In terms of curriculum setting, German universities pay more attention to the teaching of professional theoretical knowledge and the training of practical ability of students, with prominent professional characteristics. Students who are not interested in mechanical engineering or have poor learning abilities may choose to switch to other majors. Chinese colleges and universities place greater emphasis on cultivating students' comprehensive qualities and adaptability to employment during their university years, offering a wide range of courses in ideological and political education, humanities, language courses, as well as the cultivation of innovation and entrepreneurship. As an engineering major, both Chinese and German schools pay more attention to practical teaching modules, and the distribution of class hours is basically the same.

*Table 1: The proportion of course hours for mechanical engineering major at Sino-German universities, %*

| Modules of mechanical engineering students training courses | University of Shanghai for Science and Technology | Hamburg University of Applied Sciences |
|---|---|---|
| General education course modules | 27 | 5 |
| Subject basic course modules | 38 | 20 |
| Professional core course modules | 10 | 40 |
| Professional expansion course modules | 3 | 10 |
| Elective course modules | 2 | 5 |
| Practical teaching module | 18 | 20 |

## 3. Student training mode

### *3.1 Dual System*

The dual system was originally an innovative model set up by Germany to cultivate skilled workers. With the progress of the times and the continuous advancement of the economy and science and technology, enterprises have higher requirements for the quality and ability of technical talents. Technical personnel only need to have solid basic knowledge, but also need to have the ability to solve problems independently and creatively. In the mid to late 1990s, German universities began implementing a dual system of personnel training model, which could cultivate advanced technical talents. The professional training objectives were aligned with enterprises, and students combined theory with practice through continuous learning. As a result, enterprises became one of the main bodies of cultivating engineering students in universities.

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Hamburg University of Applied Sciences has established a student internship enterprise base, where students are required to complete an 18-week internship in the enterprise. Some enterprises in Hamburg, Germany, where the university is located, and surrounding areas regularly provide dual learning positions to the university each year according to their employment plans. Students can apply for internship positions from the enterprises, and the enterprises will conduct interviews and tests to determine whether to provide dual learning positions for applicants through screening. Enterprises act as the main body of practical teaching in practice, developing practical teaching plans based on the vocational training content in the Vocational Training Regulations, and providing specialized enterprise engineers as practical training teachers for students in professional practice.

### *3.2 Student ability cultivation*

Hamburg University of Applied Sciences not only pays attention to students' learning of basic theoretical knowledge,, but also requires them to be able to apply the knowledge they have learned to solve practical engineering problems. Hamburg University of Applied Sciences combines theory with practice through a dual learning system, emphasizing the importance of practice while strengthening the study of theoretical knowledge.

There are mainly two training modes, including the mode of integration of academic education and vocational qualification education, and the mode of integration of systematic enterprise practice. The first mode is more traditional, requiring students to sign training contracts with enterprises, which is the key standard of this mode. Generally, students need to study for about four academic years, including basic content and in-depth learning. After passing the graduation examination of the school and industry association, they can obtain a vocational qualification certificate. Compared with the first model, the second model is more systematic. It integrates enterprise internships into the dual-system learning curriculum. Internship and school theoretical knowledge teaching are carried out alternately to complement each other. The results of internships are counted towards university credits based on grades, and the learning time is generally three years. The difference between this mode of learning and the first mode is that graduates can only obtain a bachelor's degree certificate issued by the university, without any additional professional qualification certificates from industry associations.

In recent years, with the support of the Excellent Engineer Training Program, mechanical engineering students at the University of Shanghai for Science and Technology have also begun to enter enterprises in various ways during their studies. Due to the absence of enterprise internships in the training program, students mainly enter enterprises during vacations and graduation design stages, lacking effective organization and teaching content planning. The dual system of the combination of university and enterprise, similar to the on-the-job form of undergraduate training, few colleges and universities in China have tried.

## 4. Teacher Introduction and Training

### *4.1 Teacher application requirements*

Hamburg University of Applied Sciences is very strict in the selection of engineering teachers, emphasizing academic level, and must have practical experience in engineering. On the academic side, teachers must have a doctorate degree and pass the professorship examination of universities, or applicants must be industry experts with special qualifications. On the other hand, practical ability is required. For example, to apply for the position of full-time teacher in mechanical engineering, one must have at least five years of practical technical work experience in the enterprise.

### *4.2 Teacher teaching and research*

German university professors used to focus on teaching, but with the changing times, they now place more emphasis on scientific and technological development and technology research and development, encouraging students to engage in scientific research. During the teaching period of the professional teachers of Hamburg University of Applied Sciences, the professors will have a six-month industrial research opportunity every four years, and they can participate in technical work at companies related to their profession, conduct academic research, and learn about the latest issues and trends in their field, in order to expand their professional knowledge. In addition, professors are required to have 18 to 19 theoretical teaching sessions per week, although there is no mandatory

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requirement for scientific research, but there are certain scientific research results can be reduced some teaching tasks. Similar universities in Germany place more emphasis on teachers' scientific research abilities, and the investment in scientific research can bring better personal development[7].

### *4.3 Teacher performance evaluation*

At the end of each semester in German universities, students are asked to evaluate the teaching of professors through questionnaires. In addition, the school has also developed performance evaluation indicators to evaluate teachers from three aspects: scientific research, teaching, and social services. Linking the annual performance of teachers to their job promotion is still an important basis for salary and resource allocation. Teachers who evaluate excellent performance will get corresponding bonuses and job promotions.

The teacher management at Hamburg University of Applied Sciences is very distinctive. The school continuously promotes the career development of teachers through the role of performance, and uses annual performance evaluation rewards to enable teachers to achieve self-improvement. The performance management of Hamburg University of Applied Sciences emphasizes science and conducts scientific performance evaluation through two levels of specialized academic committees, respecting academic power, and focusing on teacher evaluation at different career stages is also different.

Shanghai University for Science and Technology also has a relatively mature teacher performance evaluation mechanism, but as a comprehensive university, the proportion of scientific research achievements in teacher evaluation is relatively high. Mechanical engineering teachers generally come directly from doctoral students who have graduated from universities, with a good theoretical foundation and scientific research ability, but lack of practical technical work experience in enterprises. So it is difficult to adapt to the German engineering teaching mode for them. With the understanding of the German engineering training model by domestic colleges and universities, they have also begun to attach importance to the practical work experience of professional teachers. The University of Shanghai for Science and Technology sponsored some young teachers to work as interns in enterprises every year to cultivate practical work experience, and achieved good results. However, there is still significant resistance in terms of personnel system when directly recruiting engineering and technical personnel with doctoral degrees from enterprises to teach in universities.

## 5. Comparison and Analysis of Teaching Systems

### *5.1 Curriculum Provision*

By comparing the courses of mechanical engineering majors in two universities in China and Germany, it is found that the curriculum modules of the two universities are basically the same. However, German universities place more emphasis on cultivating students' professional practical abilities. The University of Shanghai for Science and Technology requires students to not only master the basic knowledge of mechanical engineering, but also add compulsory courses such as humanistic literacy, ethics and law, and modern Chinese history. The curriculum systems of Hamburg University of Applied Sciences and the University of Shanghai for Science and Technology are both modular courses, students can choose courses according to the professional requirements and interests of teachers, and the university can cultivate talents in various types of fields. Elective modules allow students to expand their abilities in other areas, cultivate their self-learning ability, and be able to innovate themselves in the context of rapid technological development.

Due to the differences in social environment and national education management systems between China and Germany, the "dual system" model of engineering teaching is still in the exploratory stage at University of Shanghai for Science and Technology. In recent years, by learning from the German model and building a modern engineering talent training system based on Chinese characteristics, the school has actively adapted to the needs of national and local manufacturing industry development. While strengthening the teaching of students' basic theories and professional knowledge, the school has actively conducted joint training with enterprises and set up an industrial college. To train high quality engineering students from the aspects of practical application, vocational demand and comprehensive accomplishment, and other aspects. It is recommended to include a 10 weeks enterprise production internship in the mechanical engineering teaching plan, which will be helpful for students to master professional knowledge and improve practical abilities.

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### *5.2 Teacher quality and cultivation*

The recruitment requirements for mechanical engineering teachers at University of Shanghai for Science and Technology are to obtain a doctoral degree in engineering and possess a solid foundation of professional knowledge. In terms of academia, it is required that the applicant has published academic papers in authoritative journals, has good qualities, has a passion for education, and has obtained a university teacher qualification certificate through learning, training, and teaching internships within a period of employment before being able to teach independently. Generally, it is not required that the applicant has relevant practical work experience. Compared with the quality requirements for teachers at Hamburg University of Applied Sciences, it is suggested that when recruiting teachers for engineering majors, universities should not only have educational qualifications, but also have certain practical work experience. Teaching and research should be combined closely with the development needs of enterprises, which is conducive to making up for the lack of practical abilities of domestic university graduates.

## 6. Conclusions

In this paper the curriculum design, training mode, teacher quality requirements, and ability development of the Mechanical Engineering major at Hamburg University of Applied Sciences is investigated. It analyzes the school's characteristics, talent cultivation, and curriculum system requirements for teacher quality and ability, and explores the corresponding relationship between deepening engineering education reform and professional teacher training mechanisms. Comparing the teaching and teacher management system of the Mechanical Engineering in University of Shanghai for Science and Technology, some suggestions were put forward for improving teaching quality and enhancing teacher competence, and drawing useful conclusions.

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