

## Constructing a Functional Modular Curriculum System for Cultivating Undergraduate Innovative and Creative Talents

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**Abstract.** In deep analysis of interdisciplinary cases at home and abroad, and in view of the defects of general rules or methods that cannot be found in the interdisciplinary cases for undergraduate education and teaching, an education program of "constructing functional modular course + multi-course integration experiment" for undergraduate education and teaching is presented to facilitate the cultivation of compound talents with innovation and creativity in this paper. The functional modular course is based on engineering, that is, it is proposed on the basis of analyzing the essence of engineering problems. The knowledge elements of each functional module constitute the knowledge system of "line" type structure, which can solve the "point" problems in engineering independently. The multiple functional modules are organically integrated to solve complex technical problems in engineering. The multi-course integration experiment is corresponding to the functional modular course. It extracts the core knowledge elements of the functional modular course, and further refines the practical elements from the core knowledge elements with the thinking mode of engineering application. The appropriate combination of the functional modular course and multi-course integration experiment can realize the seamless connection of theory and practice. The education program can cultivate high-level innovative and creative technical talents with interdisciplinary disciplines.

### Introduction

Today, interdisciplinary education is a hot topic. Gaining an insight into the nature of the interdisciplinary education may help to make design decisions for the interdisciplinary education. The Amsterdam Institute for Interdisciplinary Research defined a gradual scale in which the multidisciplinary, interdisciplinary and transdisciplinary were defined as the degree of integration of different knowledge sources. In the multidisciplinary research studies, each discipline contributed a piece of the puzzle. However, this was not integrated during the research process or even in the final outcomes. The result was a parallel vision on a particular problem from different disciplinary perspectives. The interdisciplinary ways of working truly integrated ways of working and solutions at each step during the process of realizing a solution. The transdisciplinary research involved, beyond the knowledge of professional experts and scientists, a layman's knowledge to come to new innovative solutions [1]. This innovative practice category work in progress paper presented course design for an interdisciplinary course that could be offered to engineering and computer science students. The curriculum design aimed at teaching computing concepts with interdisciplinary engineering problem sets [2]. A course entitled "Science and engineering education: interdisciplinary aspects" was designed. The research used qualitative instruments to characterize students' attitudes towards interdisciplinary learning and teaching of science and engineering. According to the findings, despite the significant challenge which characterized interdisciplinary teaching, a notable improvement was evident throughout the course in the percentage of students who expressed willingness to teach interdisciplinary classes [3]. The study used a qualitative case, bound by three required courses in a new interdisciplinary undergraduate minor. Data was collected via interviews, class observations, and student reflection assignments. Analysis was guided by the conceptual frameworks of King and Kitchener's reflective judgment model and strange and banning's conceptualization of campus learning environments [4]. Another research question was how an undergraduate-level course could help computer science students better understand the multicultural and interdisciplinary scenarios that composed today's working environment [5]. Due to the complex nature of climate change, interdisciplinary research approaches involving knowledge and skills from a broad range of disciplines have been adopted for studying changes in the climate system as well as strategies for mitigating climate change (i.e., greenhouse gas emissions reductions) and adapting to its impacts on society and natural systems [6]. In addition, a novel teaching method was proposed to design the contents of the interdisciplinary courses for the specialized mechanical engineering education. The relationships and intersections among the different majors were regarded as the most important factor for teaching the interdisciplinary courses well. Refining the associated knowledge from these intersections was the core task for teachers [7]. In order to lead the new technology and

industry in the future, it was studied to promote the interdisciplinary and cross-border integration and optimize the layout of disciplines in China [8-10]. However, in the above cases, it is impossible to find the general rules or methods to be followed in undergraduate education and teaching. In response to the defect, the education program of "constructing functional modular course + multi-course integration experiment" is presented in this paper, which provides an effective way to cultivate compound talents with innovative and creative abilities.

### **Functional Modular Curriculum System**

**Constructing Functional Modular Courses.** The curriculum is the core of education and teaching, which directly determines the quality of talent training [11]. The basic functional module, professional basic functional module and professional functional module are constructed with the new concept of engineering education and the new structure of discipline and specialty. These functional modular courses are based on engineering, where core knowledge elements are first extracted from important projects, and then the knowledge elements are mapped to closely related courses, and these courses are finally integrated and set up as a functional module. Undergraduates choose courses with the functional modules as the smallest unit, break the barriers between disciplines and majors, and can choose the courses with the functional modules across majors, disciplines or even boundaries. The undergraduates should be encouraged to obtain a first degree (main degree) and a second degree (secondary degree). For each degree, the functional modules required for theory and practice should be defined, and the minimum compulsory credits for the first and second degrees should be specified. For the same knowledge element under the first and second degrees, the credits of the functional modules of the first degree should be greater than that of the second degree to ensure the depth and breadth of knowledge in the functional module of the first degree. Taking the subject of mechanical engineering as an example, "Theoretical Mechanics", "Material Mechanics" and "Fluid Mechanics" are integrated into a mechanical basic functional module, and "Digital Electronic Technology", "Analog Electronic Technology" and "Single-chip Microcomputer Principle and Application" are integrated into an electrical basic functional module. Of course, the engineering thinking mode is applied to integrate the functional modules, which deconstructs and reconstructs the course contents, extracts their core knowledge elements, and removes secondary and repetitive knowledge elements. The courses in the functional module are organically combined to form a smallest unit dealing with engineering problems.

**Constructing a Module of Multi-course Integration Experiment.** After the functional modular course is constructed, the experimental course should be changed the traditional experimental mode based on each course, and the multi-course integration experiment matching the functional modular course should be designed. Each basic function module, professional basic function module and professional function module are taken as a unit. First, the core knowledge elements of each course in the unit are extracted, and the relationship between the core knowledge elements is comprehensively analyzed. Then, the practical elements are further refined in the knowledge elements with the thinking mode of engineering design, manufacturing and application. Finally, the multi-course integration experiment is designed based on the practical elements. This kind of experiment can turn the course knowledge into engineering, so as to train undergraduates' professional basic knowledge application and engineering practice ability. Taking the subject of mechanical engineering as an example, the multi-course integration experiment module of "Product Practice and Microcomputer Measurement Technology and Application" can be constructed by integrating the courses of "Mechanical Engineering Testing Technology", "Machinery Manufacturing Foundation" and "Interchangeability and Measurement Technology Foundation".

### **Necessity and Feasibility of Constructing the Functional Modular Course**

**Need to Construct the Functional Modular Course.** The functional modular course is proposed on the basis of analyzing the essence of engineering problems. The knowledge elements of each functional module constitute the knowledge system of "line" type structure, which can solve the "point" problems in engineering independently. The multiple functional modules are organically integrated to solve complex technical problems in engineering. In the integration of the functional modules, new knowledge elements will emerge, which are the source of innovation, creation and entrepreneurship. However, the traditional teaching mode is based on the curriculum, and only the combination of multiple courses can constitute the "line" type structure knowledge system. Under the traditional education background, most students can only learn one professional knowledge during their undergraduate study, that is, they only get one degree and can only deal with "point" problems in engineering when they just graduate. In this mode, students of any major have a narrow scope of knowledge, while for innovation, creation and entrepreneurship, the knowledge base is weak and it is extremely difficult to achieve the goal. If the functional modular curriculum system is constructed, students can choose courses based on the module functions with specific and clear objectives, which is conducive to grasping the essential attributes of each module. They can also choose the functional modules of multiple subjects at the same time. The functional modular courses can provide multidisciplinary integration technical support for dealing with complex engineering problems, provide a feasible solution for cultivating interdisciplinary innovative technical talents, and also provide an effective way for undergraduates to obtain double degrees.

**Feasibility of Constructing the Functional Modular Course.** The deep integration of information technology and education teaching is changing the traditional teaching mode. For example, the Ministry of Education of China announced 468 and 690 national quality massive online open courses (MOOC) related to undergraduate education

respectively in 2017 and 2018, with a total of 1,158 in the two years [12,13]. This kind of teaching platform provides support for teaching reform, and also provides resource and technical means for exploring new teaching modes. Some teachers began to try the flipped classroom teaching method based on the MOOC or micro-course to guide students to learn online, to teach and summarize the key points and difficulties in the course or experiment in class, and then to intersperse the core knowledge discussion links between the teacher and the student or between the student and the student, which is called the mixed learning mode. Students could also use the online learning and mobile learning modes to self-learn the course contents [14-17]. Constructing the functional modular curriculum system in the context of the rapid development of the MOOC and micro-course makes it possible to cultivate composite and innovative technical talents with interdisciplinary disciplines. The teaching platform based on the MOOC or micro-course has a large amount of information, and it can not only improve the quality of teaching, but also improve teaching efficiency. The students can learn online at any time, and the learning method becomes flexible and diverse.

## Conclusions

The education program of "constructing functional modular course + multi-course integration experiment" for undergraduate education and teaching is presented to facilitate the cultivation of compound talents with innovation and creativity. The functional modular course is based on engineering, which is proposed on the basis of analyzing the essence of engineering problems. The knowledge elements of each functional module constitute the knowledge system of "line" type structure, which can solve the "point" problems in engineering independently. The multiple functional modules are organically integrated to solve complex technical problems in engineering. The multi-course integration experiment is corresponding to the functional modular course. It extracts the core knowledge elements of the functional modular course, and further refines the practical elements from the core knowledge elements with the thinking mode of engineering application. The appropriate combination of the functional modular course and multi-course integration experiment can realize the seamless connection of theory and practice. The education program can cultivate high-level innovative and creative technical talents with interdisciplinary disciplines, which can promote engineering technology innovation, industrial innovation, transformation and upgrading.

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