

# *The characteristics of engineering textbooks for applied undergraduate and the path of textbook construction*

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**Abstract:** Textbooks are an important basis for teaching and a guarantee for improving the quality of talent cultivation. There are significant differences between applied undergraduate and traditional undergraduate in engineering education. This article summarizes the characteristics of engineering textbooks for applied undergraduate and the implementation path of textbook construction. The textbooks should be designed according to the curriculum objectives and “outcome” orientation, keep up with the development of science and technology, focus on improving students' ability to solve complex engineering problems and be innovative in style and form. At the same time, the implementation path of textbook construction needs to be adjusted. It is necessary to select qualified writers, promote the dual development of colleges and enterprises, accelerate the speed of textbook updates, focus on students, and build new forms of textbooks with innovative content and form, in order to develop excellent textbooks that meet the positioning of engineering applied undergraduate talents.

## **1. Introduction**

Applied undergraduate education is a higher education that cultivates high-level applied talents in professional fields. It differs significantly from traditional research undergraduate. In China, research universities are primarily aimed at cultivating academic talents in education. In order to solve the homogenization of undergraduate education, it is necessary to develop applied undergraduate to adapt to the changes in talent supply and social demand that have emerged with the rapid development of China's economy.

In applied undergraduate universities in China, the number of engineering students accounts for a considerable proportion. Textbooks are the main carrier of teaching content and an important tool for universities to carry out high-quality teaching activities. However, the current textbooks of engineering majors for applied undergraduate are not suitable for their talent positioning and industrial requirements.

Therefore, accurately identifying the characteristics of engineering textbooks for applied undergraduate and changing the implementation path of textbook construction can ensure that universities effectively achieve their talent training goals [1].

## 2. Characteristics of engineering textbooks for applied undergraduate

### 2.1. Designing the content of textbooks based on the curriculum objectives and "outcomes" orientation

China has become a full member of the Washington Agreement in 2016, realizing the international substantial equivalence of China's engineering education professional certification. Outcomes-Based Education (abbreviated as OBE) is the core concept of engineering education certification. William G. Spady, an American scholar who has done in-depth research on OBE, proposed that "outcome" is a clear learning result, which is what learners can actually do with what they know and learn [2].

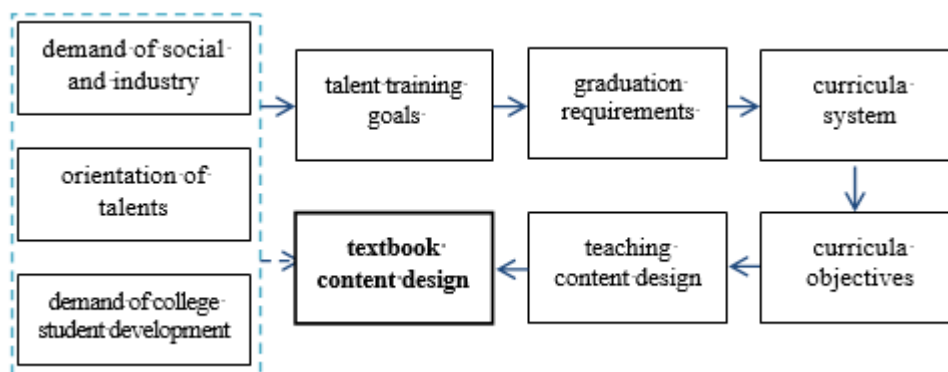


Figure 1: Logic diagram of textbook design.

The talent training goals of colleges are determined by the demands of society and industry, objectives of students' career development, and the talent orientation of the colleges. The talent training goals determine the graduation requirements, which determine the curricula system and its specific objectives of each course covered. The training goals are the educational outcomes of the major, the graduation requirements are the learning outcomes of the students, and the curriculum teaching objectives is the teaching outcomes of the course [3]. The course objectives determine the content of teaching as well as the content of the textbook, as shown in Fig. 1.

Curriculum is the core element of talent cultivation, and textbooks are the important carrier of curricula. Therefore, the construction of textbooks should follow the principle of "outcomes orientation", and content is designed according to the relevant requirements of students on knowledge, ability and quality contained in the curriculum objectives.

### 2.2. Reflecting the undergraduate orientation and structuring a knowledge system to meet the development of applied talents

Applied undergraduate is characterized by "undergraduate" and "application", that is, "high-level" and "practical ability". Although application is a common characteristic in both applied undergraduate colleges and higher vocational colleges, vocational education focuses on training talents of practical operation, and its textbooks pay more attention to "how to do" in content. However, since the undergraduate must comply with the basic requirements for studies stipulated by the state, for the same course, the mastery of theory is significantly better than that of vocational college student. So in the construction, we ought to not only prevent textbooks from becoming excessive academic like the ones of traditional undergraduates, but also prevent them from being excessive technical like the ones of vocational students. It is necessary to build the theoretical system for the professional competence of high-level applied talents according to curricula

objectives (outcomes of teaching).

Table 1: Correspondence between curriculum objectives and textbook content. (Take refrigeration principle and device as an example)

Curricular objectives	Contents designed in the textbook
1) Master the main ways to obtain low temperature and the principle of refrigeration cycle	Thermodynamic basis of refrigeration, Basic concepts of refrigeration and refrigeration cycle, Principle and working process of compressed steam refrigeration and absorption refrigeration
2) Be able to use refrigerant reasonably	Types, properties and applications of commonly used refrigerants and coolant
3) Preliminary ability to analyze and calculate refrigeration cycle	Thermodynamic calculation and characteristic analysis of single-stage compressed steam refrigeration cycle, thermodynamic calculation and characteristic analysis of two-stage compressed steam refrigeration cycle, thermal calculation and characteristic analysis of absorption refrigeration cycle
4) Master the main equipment composing the refrigeration cycle, and preliminarily have the ability of equipment selection	Type, structure and operating characteristics of condenser, evaporator, throttling mechanism, other auxiliary equipment and refrigeration pipeline system
5) Master the application of refrigeration technology in daily life and business	Practical application of refrigeration devices such as air conditioners, refrigerators and cold storages
6) Cultivate students' awareness of energy conservation, emission reduction and environmental protection	Energy saving of refrigeration equipment and New energy-saving technology

For example, in the textbook of refrigeration principles and devices for applied undergraduate students, it is also necessary to include the concept of refrigeration, main refrigeration methods, refrigeration cycle principles and working processes, common refrigerants and coolants, condensers and evaporators and other refrigeration equipment (contents designed corresponding to item 1), 2) and 4) of Table 1). The corresponding relationship between the curricula objectives and the contents is shown in Table 1.

For the students of engineering major, engineering analysis methods play an essential role. In the textbooks, there ought to be not only concept and principle but also the content of relevant discipline methodology required to solve engineering problems, especially the ideas and methods often used in the actual production process to help students establish engineering thinking awareness, so that students' professional knowledge can be transformed into professional ability [4]. In the course of refrigeration principle and devices, the objective requires students to have the ability to preliminarily make analyzing and calculating of the refrigeration cycle. Therefore, the basic performance calculation method and characteristic analysis of the commonly used refrigeration cycle system ought to be also compiled into the textbook, as shown in content corresponding to the item 3) of Table 1.

It should be noted that the textbooks ought to focus on the foundation, avoid too deep divergent relating and analyzing, and focus on the discussion of concepts, principles and their physical essence and engineering analysis methods.

### **2.3. Highlight demand-oriented application to improve students' ability to solve complex engineering problems**

Since the important goal of applied undergraduate education is to improve the practical ability of talents, textbooks could not just expound theories and are separated from practice. As we know, the learning process in the college, in fact, is also that of "learning profession". Learning "outcome" is the final learning result obtained by students and the specific application of what they learn. Therefore, the applied content ought to be designed according to curricular objective and aim at requirements of vocation and industry. Still taking the above course of "Refrigeration Equipment and Devices" as an example, in the textbooks, in order to meet the requirements of the course objectives in Item 5 of Table 1, it is necessary to compile the content including the practical application of various new air conditioners, refrigeration equipment, cold storage and other devices commonly used in the refrigeration industry.

Benjamin Bloom, a famous educator, classified "application, analysis, synthesis and evaluation" as high-level thinking ability in the level classification of cognitive field. Applied undergraduate colleges are built to cultivate high-level applied talents who have the ability to solve "complex engineering problems", i.e., be able to analyze problems, apply principles and evaluate schemes. Therefore, the application of textbooks is supposed to introduce comprehensive cases aiming at the key content of the course and reflecting the complexity of engineering problems, extract multiple typical common tasks from the cases, explore multiple solutions, and compare the advantages and disadvantages of the schemes after synthesis. If the application content of the textbook is fragmented and only gives examples for a single problem, splitting the links between chapters and knowledge points before and after, it will be difficult for students to integrate independent course content into a complete project, which is not conducive to internalizing knowledge into a comprehensive ability to "solve complex problems".

The application characteristics of the textbook are not only embodied in the main content of the textbook, but also in the exercises after class. College education is professional ability education but examination education, it is not just 'what' students remember and know. Therefore, the exercises in textbooks should focus on the problems of promoting the comprehensive use of knowledge, which needs to reduce the questions of concept or principle memory and questions with too deep and divergent understanding, to avoid students' learning by rote.

### **2.4. The renewed content which evolves with the development of times**

New technologies are emerging continuously in modern society, which results in shorter and shorter cycle of knowledge updating. It is a basic requirement for teaching to update the content in time and reflect the development of disciplines and technologies, so textbooks need also keep up with the changes in professional fields. According to the curriculum objective (curriculum teaching outcome), it is necessary for teachers to bring new concepts, new methods, new technologies, new materials, new processes and new norms into textbooks to renew outdated contents, so that they can be learned and used, i.e., students can "learn for applying". For example, for the textbook of "Refrigeration Principles and Devices", it is the basic quality requirement for students in the curriculum objectives to establish the awareness of saving resources and reducing energy consumption, so content about practical new technologies for energy conservation and emission reduction in refrigeration and air conditioning must be compiled into the textbook, as shown in Table 1, the content corresponding to curriculum objective 6.

It cannot be separated from training of innovation ability to cultivate outstanding engineering technology talents, one of the important goals of higher education, which requires the textbooks to contain forward-looking content such as the development trend of technology, new technologies

that will appear in the future. Only in this way can the teaching content be connected with the demand for industrial technological innovation and industrial upgrading, and can the technological innovation potential of college students be effectively stimulated.

## **2.5. To take students as the center, innovate the textbooks compilation style, and change the textbooks form**

For higher education, teaching is not a unilateral knowledge output of teachers, but an interaction between teachers and students. Students are the main body of learning, so the construction of textbooks ought to conform to the changes of the times and reflect the new concept of "student centered" in engineering education.

### **2.5.1. Innovating the design of textbooks style**

The content of existing undergraduate textbooks is usually expressed in a simple, straightforward way, setting out concepts, formulas, principles and other knowledge points one by one, which makes the textbooks very boring. Since the student-centered concept requires consideration of students' cognitive laws, learning process and learning psychology, the way of listing and introducing knowledge points one by one in textbook compilation needs to be changed. It can be designed in the type of creating problem scenarios. At the beginning, the content is introduced through representative production practice projects, and then students are guided to think actively by "asking questions"; in the text, the questions raised at the beginning are analyzed, which strengthens the students' understanding of the principles and the background of engineering application. The textbook is compiled in a form that is closer to practical application and more problem oriented logic, which helps to change the passive one-way indoctrination of teaching activities into active two-way participation, and play the more effective role of the textbook in promoting teaching.

### **2.5.2. Changing the form of textbook design**

With the wide application of information technology in life and education, the behaviour, learning style and reading habits of college students growing up in the Internet era are quite different from those before; At the same time, the individual differences of students' academic foundation are relatively large. Therefore, the construction of textbooks should conform to the characteristics of the Internet era, which requires us to fully consider students' learning experience, and change the single paper form of traditional textbooks (i.e., to build new forms textbooks). In new form textbooks with integrated design, the paper textbook and digital resources are fully integrated together by means of information technology. Digital resources can make up for the limited information of paper textbooks; Digital resources are presented in a more dynamic and intuitive way, which can enhance students' learning effect; Digital resources display is not limited by the class time, which increases the learning flexibility. The revision cycle of paper textbooks is generally more than three years, so it is impossible to update the content in real time, while the convenience and timeliness of digital resource modification enable the teaching content to synchronize with the technological frontier to the greatest extent.

The new form textbooks overcome the shortcomings of personalized service, space and functions of paper textbooks, and has also promoted the reform of classroom teaching methods.

### **3. The implementation method of the construction of engineering textbooks for applied undergraduate**

#### **3.1. Selecting qualified authors with sufficient teaching background and rich compiling experience**

Different from other reading materials, the primary function of textbooks is to meet teaching requirements and help students master the content with maximum transfer value in limited time. Therefore, an excellent textbook must have a rigorous system structure, logical presentation order, consistent content selection with orientation, refined language expression, professional terminology, and be able to stimulate students' enthusiasm for learning with a writing style that students are willing to accept. This requires that the author must have a solid professional foundation, rich teaching experience, be familiar with the compilation of textbooks, and have in-depth thinking about the problems and characteristics of the current applied undergraduate textbooks. Only by this way can the author take all process into consideration from teaching to textbooks, from the whole to the part, and from content to form.

Compared with research universities and higher vocational colleges, there are no mature textbooks of applied undergraduate for reference. Only by carefully selecting authors can we compile innovative textbooks that meet orientation of applied undergraduate talents.

#### **3.2. College enterprise cooperation and joint development to increase the revision frequency of textbooks**

The content of textbooks for applied undergraduate is designed based on demand. The advantage of college teachers is that they understand teaching, have a high theoretical level, but have little practical engineering experience, and lack a comprehensive understanding of job requirements and front-line production. The mode of college-enterprise cooperation in higher education can make up for these deficiencies and play a complementary role in personnel training. Actually, this mode of closely combining theory with practice has successful experience in the United States, Germany, Britain and other countries.

The participation of engineers with more practical experience in the construction of textbooks can promote the connection between the curriculum and industry standards, production processes, project development, accelerate the updating of teaching content, and also push forward the connection between the content of textbooks and the actual needs of enterprises and production. However, it should be noted that the participating enterprises must be the leaders in the industry, because these enterprises are leading in technology and have representative talent needs.

If the content of the textbook is not updated in time, it is inevitable that the textbook will become outdated. So it is necessary to improve the frequency of textbook revision and shorten the interval of revision cycle.

#### **3.3. Building new form textbooks with rich contents and diversified presentation forms to expand teaching contents and solve teaching difficulties**

The construction of new form textbooks is a part of the teaching solution. Based on paper textbooks, content including teaching cases, classroom discussions, teaching materials, homework, etc. can be designed into digital resources of new form textbooks which can also contain supplementary information on cutting-edge scientific and technological developments that cannot be updated in time in paper textbooks. The digital resources of the new form textbooks can be presented in the form of pictures, text, animation, video, etc. according to the content characteristics.

Many complex components and parts, equipment, working principles and working processes that cannot be described vividly and concretely in the textbooks are difficult and abstract for students to understand. They can be made into videos or three-dimensional animations by virtual simulation, augmented reality and other technical means.

By mobile internet technology, the videos and animations can be embedded in the paper textbooks in two-dimensional codes, which can be played and presented after students scan the two-dimensional codes. This way eliminates the obstacle that students cannot “watch”. It makes the difficult learning content intuitive, visual, dynamic and easy to understand.

In some difficult points or key points, two-dimensional code can also be inserted to supplement the content of the textbook to change its lack of flexibility.

#### 4. Conclusion

The content and form must be reconstructed reasonably according to cultivation goal in the construction of engineering textbooks for applied undergraduate, so as to meet the teaching needs and adapt to the development of the times. It is a complex, rigorous and systematic work, which requires the overall consideration of the selection of authors, the innovation of compilation mode, the planning of form and content to achieve good results.

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