The Construction and Practice of Integral Knowledge Course Teaching Model with the Core of Innovative Ability Training

Kun Liu\textsuperscript{1,a} and Liwen Zhou\textsuperscript{1}

\textsuperscript{1}College of Materials and Metallurgy
University of Science and Technology Liaoning, Anshan City, Liaoning Province, China
Post Code 114051
\textsuperscript{a}lk651206@163.com

Keywords: Metallurgical transmission principle; innovation ability training; integral knowledge; examination mode

Abstract. This paper takes the Metallurgical Transmission Principle course of metallurgical engineering major as an example, transforming the idea of education from over-division of knowledge and lack of connection to emphasis of integrity of knowledge and ability to use knowledge to solve practical problems. It focuses on the implementation of classroom teaching reform, and reconstructs the course content system. It realizes the innovation of teaching theory and teaching link, and improves the teaching level of teachers, comprehensively improving the quality of education. It aims to cultivate outstanding innovative engineering and technical talents, and has explored an integral knowledge training model of college students' innovative practice ability with the core of innovative ability training.

1. The Proposing of Subject

Contemporary college students shoulder the historical mission of the great rejuvenation of the Chinese nation. Cultivating the innovative spirit and entrepreneurial ability of college students is the primary task of higher education. As early as February 17, 2007, the "Opinions on Further Deepening Undergraduate Teaching Reform to Improve the Quality of Teaching Comprehensively" issued by the Ministry of Education clearly puts forward that we need to promote the talents training model and mechanism reform, and create conditions to organize students to actively...participate in innovative science experimental research, and focus on cultivating students' innovative spirit and innovation ability[1]. Innovation and entrepreneurship education research has become the focus of higher education research. It is an important plan made for innovation and entrepreneurship talents training in the 18th National Congress of the Communist Party of China to perfect the innovative entrepreneurship education curriculum system and strengthen the innovative entrepreneurship practice education. Innovation and entrepreneurship education has made positive progress in colleges and universities in recent years, which plays an important role in improving the quality of higher education, promoting students' comprehensive development and graduates' employment and entrepreneurship, and serving national modernization. But there are some prominent problems that can’t be ignored. For example, the concept of innovation and entrepreneurship education is lagging behind, not tightly connected with professional education, and lacks of strong pertinence and effectiveness; there are few practice platforms, losing touch with practice; innovation and entrepreneurship education system needs to be improved urgently. At present, improving the quality of higher education and cultivating graduates with innovative ability who adapt to social development have become the common concern of education sector and society[2]. The traditional curriculum system can only let students get some old, fragmented knowledge. It can’t help to improve their overall quality, including open life vision, thinking and expression ability, mature personality and innovation ability. Students' professional learning is a process to expand and deepen knowledge. In the course of learning, students' knowledge system experiences a process of qualitative change from disordered to organized, superficial to deep, fragmented to convergent. To achieve this process, and train college students who have solid foundation profession, strong practical ability, and are able to
adapt to work environment faster after graduation and use their own expertise to finish the work easily, we need to break the divided situation of traditional courses in course teaching, and conduct organic combination of content. It requires teachers to get rid of the traditional teaching mode, and transform the idea of education from over-division of knowledge and lack of connection to emphasis of integrity of knowledge and ability to use knowledge to solve practical problems[3-7].

2. The Construction of Talents Training Course Teaching and Management Model with the Core of Innovation

The professional basic course Metallurgical Transmission Principle which is opened for excellence program undergraduates of metallurgy major also participates in school examination reform and construction. It’s not only reflected in the diversified evaluation methods of students’ course grade. What’s more important is it establishes research-based course in daily teaching process to cultivate students’ abilities. Under the guidance of the teaching idea, it re-optimizes and integrates teaching content, reforms classroom teaching method, sets up the topic of research-based teaching and builds research-based metallurgical transmission principle teaching mode which improves the assessment method.

The guiding ideologies of its specific teaching philosophy are as follows:
(1) Pay attention to thinking training, and emphasize a solid foundation. The focus of teaching is to cultivate students to establish the unity of three-transmit theory and similar thinking, and methods and ideas of using basic three-transmit theory to solve practical problems, paying attention to cultivating their quality and ability on science and technology.

(2) Achieve “integral knowledge” in teaching content from vertical and horizontal directions. In the vertical direction, infiltrate part of the content of follow-up professional courses and professional elective courses; from horizontal direction, connect metallurgical transmission principle with other professional courses, closely integrated with real life; bring the classroom teaching of metallurgical transmission principle into the broad development background of material disciplines, and introduce the latest scientific research progress of related disciplines of material discipline into classroom teaching.

(3) Integrate teaching content, reform teaching methods, set up the research topic, change the assessment methods, and let innovative ability training run through all the links of teaching.

The specific teaching methods and implementation program are as follows:
(1) Use cooperative teaching methods: based on the voluntary principle, organize relatively fixed learning group to have cooperative learning in a variety of teaching activities. Even answering question in class also adopts the mode of group cooperative learning. For example, each member of the group earns 1 point if any member of the group or several members answer one question correctly; if any member of the group is absent once regardless of any reason, every member of the group will be deducted 1 point; being late for class twice equals one absence. Focus on students, support students to conduct self-learning, collaborative learning and inquiry-based learning. Whether homework or after-school study, all adopts group cooperative learning method, so as to strengthen students’ team spirit, promote students’ active participation and personality development. The teaching management method has received very good results in practice. It mobilizes students’ interest to learn.

(2) Use research-based teaching methods: after the teaching of basic knowledge of the chapters, the teacher gives several topics that need to be studied and discussed, and students complete the topics after learning related knowledge by searching for literature using network resources. Let students prepare speech draft and collect supportive literature, so as to increase students’ ways to gain knowledge. Let students collect materials using library books, e-journals and network resources, and then finish the summary, improving their induction ability, which is of great help to the future curriculum and graduation design. And organize seminars of different levels in teaching. Ask each member of the group to make a speech within 4~5 minutes, aiming to examine each student’s mastery degree of the spoken content and whether the narrative content of each member presents systematic
coherence. Let students learn in competition, give full play to students' subjective initiative, and develop students' self-confidence, cooperative ability, communication ability, innovative ability and comprehensive practical ability.

(3) Use integral knowledge teaching methods: combine different contents of course with different teaching method in teaching from horizontal direction, and combine basic course and professional course organically from vertical direction and extend them into the application area of professional selective course. Teaching links such as experiment, internship, graduation project and extracurricular practice, need to expand related knowledge content and application area, namely combining basic and professional, theory and practice, curricular and extra-curricular, teaching and practice, learning and innovation.

3. Metallurgical Transmission Course Teaching Model Which Reflects Integral Knowledge

In the process of teaching metallurgical transmission principle with the core of "integral knowledge", take the content of momentum transmission as an example. The part includes five chapters: the first chapter is momentum transmission. It first introduces fluid’s three characteristics "liquidity", "compressibility" and "viscosity", and then leads to three assumed model "continuous media model", "incompressible fluid model" and "ideal fluid model". The course arrangement of the second chapter identifies the mainline of courses. It starts with the basic laws of natural science, namely law of mass, energy and momentum conservation, and uses control volume and system analysis method, differential and integral analysis method and dimensional analysis method. It also divides momentum transmission into several levels to lead to other four chapters. The key teaching points of chapter 2 are embodied in the basic ideas and thinking mode of "micro-analysis", "continuity", "conservation" and "transportability" in basic ideas and equation of fluid movement. In the process of deriving and mastering "continuity equation", "Bernoulli equation", "momentum equation", inspire and guide students to think through "problem-style" teaching. For example, the derivation process of fluid continuity differential equation, momentum differential equation and Bernoulli equation mainly involves mathematical and physical basic knowledge. Teacher can explain the derivation process; and about the theoretical basis, applicable conditions and physical meaning of the deducted equation, teacher can inspire students to get the answer themselves based on the assumptions in derivation process and physical quantities involved in fluid differential equation. In this way, the students not only will not feel bored with the cumbersome and boring formula derivation process. On the contrary, they will be interested in every step of the derivation process, so that students can clearly know the ins and outs of important knowledge, and keep the conclusive content in mind. The key teaching point of chapter 3 is the practical application of three equations in incompressible fluids in one-dimensional tubes. The teacher needs to explain to the students why use "Bernoulli equation" in the flow of actual incompressible fluid in the tube, rather than the momentum equation of actual incompressible fluid. These leads to the famous experiment of Renault and the expression of Reynolds number, so that the mechanism and law of laminar flow and turbulence can be discussed separately, and finally calculate various pipelines. In the implementation of teaching method, after years of teaching research and discussion, it is considered that the more advanced teaching method is to focus on students in classroom teaching and let the teacher guide the students. For the teaching content of momentum transmission, try to restore and reproduce the discovery and solving process of scientific problem, turning teaching process into the process that teacher and students explore together. For example, in order to enable students to understand the application of "Bernoulli equation", there has been such a problem: for the actual incompressible fluid flow in a steady straight circular pipe, its flow equals everywhere in the application of "Bernoulli equation". But actual fluid is sticky, and its flow rate stays the same with resistance. How to explain that? Under the teacher's guidance, some students can quickly come to the conclusion that the flow is driven by pressure differential and it overcomes the resistance during the flow to maintain constant flow. Chapter 4 is the specific application in compressible fluid flow in one-dimensional tubes. The key
teaching point is that the different movement law of compressible and incompressible fluids in one-dimensional steady tube is because density varies with temperature and pressure, resulting in a difference in the basic equations; fluid motion law is different; the former is flow driven by pressure differential, and the latter is flow driven by pressure ratio; the actual problems they solve are also very different. And combine the flow conditions of compressible fluid in one-dimensional shrinkage-divergent nozzle with application of actual steelmaking oxygen gun. Chapter 5 is a similar theory and dimension analysis. The similarity theorem and model research method are used to deal with the experimental data and conduct model test. It also combines the self-stimulated and stability phenomena with Nicholas test curve and on-way resistance formula in chapter 3. The boundary layer theory is merged into the heat transfer and heat convection section, and flow boundary layer and thermal boundary layer are unified to reveal the similarity and uniformity between the thought of boundary layer and the transfer of momentum and heat. For example, there is similar mathematical model in the mathematical description of flow and heat transfer, and their physical quantity resistance coefficient and heat transfer coefficient have analogy relationship, which allows it to better reveal the nature of the two transmission processes and simplify the laws.

4. **Embody the Integral Knowledge of Basic Courses and Professional Basic Courses**

Take the professional basic course of metallurgical engineering major Metallurgical Transmission Principle as an example to illustrate the specific measures of the topic in this regard. The contents of Metallurgical Transmission Principle include momentum, heat and quality of transmission. Taylor series expansion is used in the derivation process of basic equations of static mechanics in chapter 1 and continuity equation and momentum equation in chapter 2. Before teaching this part of knowledge, the teacher should inform students that it will involve Taylor series expansion in higher mathematics in advance, and ask students to review Taylor series expansion. Then the teacher guides students to conduct force analysis of control volume, and asks students to write out the expression of forces on each side. In the process, the teacher can tell students to simplify the expression of the force with Taylor series, so as to eventually finish the derivation of the corresponding formula. Through the derivation, let students understand how to apply basic knowledge to the learning of professional basic courses and even professional courses, which also helps to develop students' thinking and ability to apply knowledge to solve specific problems. The combination of basic course and professional knowledge is also reflected in the learning process of gas dynamics in the fourth chapter of Transmission Principle. The basic equations of gas are involved when learning the chapter of gas dynamics. The knowledge has been mentioned in the Physical Chemistry. Before starting this course, the teacher needs to ask students to review relevant knowledge points in Physical Chemistry such as gas state equation, so as to lay certain foundation for the learning of the fourth chapter of Metallurgical Transmission Principle and help to improve students' understanding of knowledge they learn in professional basic course.

The above teaching examples fully embody the novelty and advanced nature of the teaching method of "integral knowledge of basic course and professional basic course". Students can better understand the application of basic course knowledge in professional basic course in teaching activities, which helps students to study systematically and master relevant knowledge.

5. **Embody the Integral Knowledge of Professional Basic Courses and Professional Courses**

The basic course is the bridge between professional courses and basic courses. The principles and methods of professional basic courses are mainly from the learning of basic courses. The professional basic course is the learning tool of professional course. Without profound knowledge of professional basic courses, it is difficult for the students to learn the knowledge of professional courses well, not to mention applying professional knowledge in the practical. There are some related knowledge points in metallurgical engineering's professional basic course Metallurgical Transmission Principle and its professional course Iron and Steel Metallurgy. The specific link is embodied in the learning process of
the fourth chapter of Transmission Principle - gas dynamics. One knowledge point of the chapter is the flow of gas in the divergent nozzle. In the professional course Iron and Steel Metallurgy, the oxygen lance used in steel-making is a divergent nozzle. Therefore, the design of oxygen lance will involve the knowledge of the fourth chapter of Transmission Principle. Therefore, when explaining this part of content, the teacher combines the several cases of gas flow in divergent nozzle with specific conditions involved in oxygen lance design. When explaining the heat transfer, the teacher combines with the cooling of blast furnace wall when it comes to the thermal conductivity of multi-layer cylindrical wall, and combines with secondary cooling and heat transfer of continuous casting when it comes to heat convection.

At the same time, this paper puts forward and tries to use the teaching model of combining professional theory teaching and practical engineering problems, introducing practical engineering questions into the theory teaching link to stimulate students' subjective initiative and professional interest and improve students' theoretical knowledge application ability and engineering practical ability. For example, combine the transmission theory in the course of Metallurgical Transmission Principle with the process and equipment of steel-making and iron-making, combine the theory with the actual process or equipment, so as to develop students' ability to learn independently and their ability to analyze and solve problems; based on the similarity principle of momentum transmission principle, this paper puts forward "how to test the flow field of steelmaking tundish"; based on the knowledge of incompressible fluid flow in momentum transmission, this paper puts forward "key steps and methods to design converter oxygen lance"; based on three heat transfer methods, the paper proposes "show metallurgical process of different cooling zone of continuous casting based on heat transfer method"; based on mass transfer, the paper proposes "way to improve the permeability of blast furnace burden". Through the combination of the above same major basic courses and related majors, ask students to search information and understand the relevant equipment and technology in advance through self-learning. When explaining the theory of professional basic courses, infiltrate the content of professional courses, and systematically complete the above topics in group. Then develop a study report in accordance with the form of "overview of equipment technology - based theory - model development - solutions - innovative description - specific conclusions". In the class, based on teaching progress, the teacher guides students to ask and answer relevant questions and make discussions, so as to train students' professional quality, broaden their professional knowledge, stimulate self-learning ability and enliven class atmosphere.

The above teaching examples are the specific applications of "integral knowledge of professional basic course and professional course". The teaching mode has deepened the students' understanding of the professional basic knowledge they learn, and trained students' thinking to use professional basic theory to solve professional problems. It also helps students better understand how professional basic courses serve professional courses. It lays good foundation for the learning of later professional courses, which is more conducive to the learning of professional basic courses and professional courses.

6. Build Diversified Curriculum Examination Mode

In the assessment, the final closing test accounts for 40%, usual performance (attendance and classroom questions account for 10%, mid-term test accounts for 10% and comprehensive essay accounts for 10%) accounts for 30%, experimental part accounts for 10%, seminar accounts for 20%.

Diversified performance assessment. Table 1 is curriculum performance assessment quantitative indicators. In order to strengthen the classroom teaching management, it increases the proportion of usual performance. Table 2 is seminar assessment indicators.
Table 1. Structured results proportion distribution.

<table>
<thead>
<tr>
<th>Assessment type</th>
<th>Attendance and classroom questions</th>
<th>2 tests</th>
<th>Comprehensive essay</th>
<th>Seminar</th>
<th>General comment</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Attendanc e</td>
<td>Reward</td>
<td>Percenta ge</td>
<td>Student</td>
<td>Teacher</td>
</tr>
<tr>
<td>Attendance and classroom questions</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
</tr>
</tbody>
</table>

Note: faithfully record attendance. Deduct 1 point for absence regardless of any reason; reward 1 point when answering a question correctly, with the upper limit of 10 points. The experiment accounts for 10 points, the final closing test accounts for 40 points (Let students and teachers set questions together, students’ questions accounts for 60 to 70%, and teachers’ questions accounts for 30 to 40%).

Table 2. Group discussion results assessment indicators.

<table>
<thead>
<tr>
<th>Final design grade</th>
<th>Group discussion content writing quality</th>
<th>PPT production quality</th>
<th>PPT self-statement</th>
<th>Question answering</th>
<th>Task division and contribution</th>
<th>General comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percentage</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>100</td>
</tr>
</tbody>
</table>

7. Conclusion

The integral knowledge course reform with the core of innovative ability training realizes the teaching theory innovation. Change the perspective, and focus on cultivating students' integral capacity and training students' interest to apply knowledge to solve practical problems, so as to achieve teaching link innovation. It reconstructs the curriculum content system, and the contents and methods of traditional teaching evaluation. Through the curriculum reform based on integral knowledge, it has initially realized the innovation of application-oriented talents training mode.

8. References


