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Practicing education of the mineral processing engineering discipline in Henan Polytechnic University

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ABSTRACT
A plan for national education to train outstanding engineers has been put into practice at Henan Polytechnic University (HPU). Practical education is a basic characteristic of engineering education. This paper proposed ideas and models to reform the mineral processing engineering education system and also described the discipline and the objective of cultivating students for careers in mineral processing engineering. On the basis of a survey and analysis of the quality of graduate student cultivation, we established a practical teaching system of ‘four levels, seven categories’ and the effect of this system was initially apparent.

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1. Introduction

Henan Polytechnic University (HPU), with a long history of 110 years, is the earliest higher college in Henan province. Its former is Jiaozuo Coal Mining School which was established by the British Syndicate Co. Ltd., in 1909. HPU is located in Jiaozuo City, a newly-developing industrial and national excellent tourism city in the northwest of Henan Province (http://www2.hpu.edu.cn/en/contents/5240/90654.html). HPU has three campuses, 74 undergraduate majors, more than 40,000 full-time students, and its acreage is more than 4,100 mu.

The discipline of mineral processing engineering at HPU was founded in 1994. The department was authorized to grant master’s degrees and doctorates in 2001 and 2005, respectively. The Post-Doctoral Research Station of Mining Engineering was established in 2007. In 2008, the department was listed as one of Henan Province’s Featured Majors to be developed (Zhang, Zhang, Ma, Pan, & Liu, 2010) and then was upgraded to the National Featured Major in 2010. In 2013, this major was selected as a comprehensive reform pilot project of Henan Province (Lu et al., 2015). In 2016, the pilot project was successfully assessed by the China Engineering Education Accreditation Association according to ‘the Washington agreement.’

The mineral processing discipline at HPU is characterized by mineral processing and clean coal technology. It has achieved a number of provincial scientific research platforms, including, for example, ‘mining engineering materials’ and ‘mineral processing engineering’
and mining materials’ as key laboratory disciplines at the Henan Province, Key Laboratory (Engineering Center) at Henan University.

The mineral processing discipline has a strong engineering background. Almost all of the graduates work in the field of engineering design or work in practical engineering in coal preparation and mineral processing plants (Duan et al., 2010). Therefore, practical teaching is important for the cultivation of a spirit of innovation and to enhance the practical engineering abilities of students. After 20 years of development, cultivation of HPU’s discipline of practical engineering has been gradually established and perfected.

2. Discipline positioning and objective of student cultivation

To meet the demands of social and economic development, and to keep pace with the scientific and technological developments of mineral processing engineering, we established the objective to cultivate compound and applied talents. By studying basic theory and strengthening engineering practice, undergraduates should be able to develop a strong practical ability to solve complex engineering problems. A cooperative consciousness and spirit should be cultivated through several kinds of practical teaching links, academic competitions, and other activities. A variety of innovation platforms should be established to lead students to take an active part in scientific research activities, in which they should be able to develop their scientific and technological innovation and enhance their competitive advantage in the employment market. In this process, graduates should develop a concept of continued learning and diligence. They should strive for positions as project managers or technical directors, obtain mid-level professional and technical positions, or continue to study for a master’s degree and doctoral degree five years after graduation. At the same time, students should obtain the ability to compile technical proposals for large mineral processing projects and to organize such projects by implementing them independently. These specific abilities are demonstrated in the following eight categories:

(1) Use of natural science knowledge, such as mathematics, physics, chemistry, and mechanics, to analyze and solve complex engineering problems in the exploitation and design processes of mineral processing engineering.

(2) Ability to conduct mineral analysis, testing, and identification using mineral resources processing and related basic theoretical knowledge, including technical and economic evaluation on mineral resource characteristics.

(3) Application of basic principles and methods of mineral processing when designing reasonable utilization programs for mineral resources and when analyzing and evaluating the influence of these projects on society, health, safety, law, and culture.

(4) Ability to solve complex engineering problems in ore dressing practices, on the basis of scientific principles and methods, by predicting, simulating, and optimizing techniques (Cheng, Xie, Si, Zhang, & Ran, 2016).

(5) Use of principles of project management and economic decision-making methods for mineral and coal preparation, plant design, operation, and management, and ability to evaluate its effect on the sustainable development of environment and society.
(6) Possession of humanism and social responsibility, and ability to follow professional ethics and norms in engineering practices.
(7) Demonstration of the role of individual, team members, and director under a multidisciplinary background. Effective communication and exchanges with peers and the public as well as a cross-cultural background is necessary.
(8) Possession of consciousness of self-learning and lifelong learning, and the ability to constantly learn and adapt to new developments and to keep up with the newest theories and technology and the latest in international dynamics.

3. Survey and analysis of graduates cultivation quality

To comprehensively understand the cultivation of quality graduates, and to obtain graduate student evaluations from employers, am the third-party organization is consigned by HPU to issue Annual Report on the Employment Quality of Graduates every year (Duan, Zhao, He, & Ye, 2010). The detailed data and information about students employment, feedbacks form the employers and graduates is included in the report. The survey results reviewed graduate student advantages and disadvantages and provided a detailed summary and analysis. Some information is copied from the report.

Rate of student obtain employment maintains 98% above.

The evaluation of 2017’s graduates on practical teaching is shown in Figure 1.

The graduates satisfaction in the practical teaching is 91.58%. It can be seen that HPU’s practical teaching content, laboratory, practice base, etc have been widely recognized by graduates. They thought that the production practice, curriculum design and cognition practice should be strengthened. Employers highly appreciated the learning ability and adaptive ability of graduates, but innovation ability, communication skills and professional skills need to be improved.

![Figure 1. The Satisfaction of 2017’s Graduates on Practical Teaching of HPU.](image-url)
3.1 The social competitive advantages of graduates

Mineral processing engineering graduates at HPU offer the following social competitive advantages:

(1) Graduates are highly respected and widely accepted by employers.

The majority of HPU graduates are employed by companies and public institutions in the fields of coal, metal, and nonmetallic minerals. The industry and community have praised their abilities. Some of these graduates hold leading technical positions and have been awarded honors and positions that correspond to their excellent talents and work performance.

(2) Graduates are knowledgeable, are responsible, and can solve complex engineering problems.

According to the survey, the graduates have mastered the theoretical basis of engineering and the ability to solve complex engineering problems.

(3) Graduates possess a strong spirit of teamwork.

This discipline stresses the cultivation of undergraduate team consciousness, and students have realized that teamwork is essential while they are still undergraduates. Graduates learn from each other and jointly improve skills and demonstrate the ability to analyze and solve problems together. At the same time, graduates have developed strong communication skills and a capacity for social adaptation.

(4) Graduates can bear hardships and withstand painstaking work conditions.

Most graduates work in geological mining, coal, and other painstaking industries. This hard work demonstrates that the graduates are disciplined.

3.2 The social competitive disadvantages of graduates

Mineral processing engineering graduates at HPU face the following social competitive disadvantages:

(1) The ability to practice engineering needs to be strengthened.

A significant difference between engineering and science is the practice of engineering, and this combination of theory and practice is the soul of engineering. Mineral processing engineering graduates should have the following capabilities: basic experimental ability, engineering designing and planning ability, implementation of the plan, practical ability, equipment operation and maintenance capabilities, and so on. Although students possess
the basic qualities of engineers after four years of study, a larger gap exists between these basics skills and actual production requirements. Additionally, 80% of employers believe that the ability of students to practice engineering should be strengthened.

(2) Communication and organization ability is poor.

Projects often involve various aspects, multiple disciplines, and multiple departments, and therefore, these projects cannot be realized without cooperation. These skills have not been obtained in the program, and most graduates lack this ability (http://www6.hpu.edu.cn/web5/info/10458/87430.htm).

4. The construction of a practical teaching system

4.1 The practical teaching system

On the basis of this research, we established a practical teaching system of ‘four levels, seven categories.’

‘Basic skills’ includes the experimental methods and data processing of physics and chemistry experiments; and basic knowledge of electrical practices and electronics, mechanical skills, engineering drawing, computer technology, and mechanical design.

‘Professional comprehensive ability’ includes the knowledge of mineral processing unit operation and the ability to select processes and equipment; advanced mineral processing methods, mineral processing principles, and typical ore dressing process flowsheets; and basic processes of mineral processing plant design.

‘Scientific innovation ability’ includes a spirt of innovation; basic methods and skills of mineral processing experimental research; and the ability to develop new techniques and equipment.

‘Engineering application ability’ includes a familiarity with the market and user performance requirements; the ability to execute practical projects; and the capacity to deal with unexpected incidents. The cultivation of this ability is realized through the practice teaching system shown in Table 1. The detailed content of the practical teaching is shown in Table 2. The practical teaching is distributed in eight terms (four years), including experiments, Course Design, Practice, etc. The total credits are 54. The experiments are conducted in the laboratories. Acquaintanceship Practice,

Table 1. The Practicing Teaching Model of Mineral Processing Engineering at HPU.

| No. | The Practical Teaching Module | The Practical Teaching Target | The Practical Teaching Procedure |
|-----|--------------------------------|--------------------------------|----------------------------------|
| 1   | Social practice                | Understand social needs and demonstrate accomplishments in the humanities | Social practice activities and enterprise practice |
| 2   | Engineering practice           | Cultivate the ability to analyze and solve problems independently | Course experimentations and concentrated practical teaching |
| 3   | Professional practice          | Strengthen the ability for professional learning and engineering practice | Professional practice, courses, and graduate design |
| 4   | Development of integrated quality | Cultivate a spirit of innovation awareness, research, and collaboration | Scientific activities, professional skills competition, and scientific research |
Production Practice, Graduation Practice, Coal Testing Technology, Engineering Safety and Environmental Protection, Case Study of Mineral Processing Practice, and Concentrator Electrical Equipment and Automation Training of Mineral Processing Plant are accomplished together in plants by professional teachers and enterprise mentor. Meanwhile, assessments of these courses are accomplished by them.

To assess the Development of integrated quality, HPU issued the regulations ‘Undergraduate integrated quality credit recognition and implementation methods’. The minimum requirement for graduation is 5 credits. The detailed content is described in Table 3.

The awards of undergraduates are listed in Table 4.

### 4.2 The implementation effect

(1) Improve undergraduates’ operational ability.

The university set up a special laboratory fund to encourage teachers and students to actively participate in laboratory work each year. According to their interests in specific problems or scientific research encountered during actual production, students design an experimental scheme independently and conduct the experiments after instructor approval. In the past three years, more than 350 people participated in these innovative and ‘free exploration’ experiments.

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| Term            | Course Names                                      | Credits | Weeks or credit hours |
|-----------------|---------------------------------------------------|---------|-----------------------|
| First Term      | Military Training                                 | 2       | 2 weeks               |
|                 | Inorganic and Analytical Chemistry Experiment     | 1       | 24 credit hours       |
| Second Term     | Course Design of Descriptive Geometry             | 1       | 1 week                |
|                 | and Engineering Drawing                          |         |                       |
|                 | Physical Experiment- I                            | 1       | 24 credit hours       |
| Third Term      | Engineering Foundation Training and Practice      | 2       | 2 weeks               |
|                 | Physical                                          | 1       | 24 credit hours       |
|                 | Engineering Experiment- II                        |         |                       |
|                 | Coal Chemistry Experiment                         | 1       | 20 credit hours       |
|                 | Organic Chemistry Experiment                      | 0.5     | 10 credit hours       |
|                 | Mineralogy and Petrology Experiment               | 1       | 20 credit hours       |
| Fourth Term     | Practice Teaching of Ideological and Political Theory Course | 2       | 2 weeks               |
|                 | Physical Chemistry Experiment                     | 1       | 20 credit hours       |
| Fifth Term      | Acquaintanceship Practice                         | 2       | 2 weeks               |
|                 | Gravity Separation Experiment                     | 1       | 20 credit hours       |
|                 | Mineral Material Processing Experiment            | 1       | 20 credit hours       |
| Sixth Term      | Electrical and Electronic Technology Training     | 2       | 2 weeks               |
|                 | Flotation Technology Experiment                    | 0.5     | 10 credit hours       |
|                 | Mineral Processing Experiment                      | 1       | 20 credit hours       |
|                 | Course Design of Mineral Processing Technology    | 3       | 3 weeks               |
| Seventh Term    | Coal Testing Technology                           | 2       | 2 weeks               |
|                 | Engineering Safety and Environmental Protection   | 2       | 2 weeks               |
|                 | Case Study of Mineral Processing Practice          | 3       | 3 weeks               |
|                 | Concentrator Electrical Equipment and Automation  | 3       | 3 weeks               |
|                 | Training of Mineral Processing Plant              |         |                       |
|                 | Production Practice                               | 6       | 6 weeks               |
| Eighth Term     | Graduation Practice                               | 4       | 4 weeks               |
|                 | Graduation Design                                 | 10      | 10 weeks              |
| Totals          |                                                   | 54      |                       |
Continually improve practical ability.

At present, five engineering practice education centers have been set up, including Henan Energy and Chemical Industry Group Co. Ltd.; China Pingmei Shenma Group; Datong Coal Mine Group; Shanxi Coal-bed Gas Group Co., Ltd.; and Yuntai Mountain Tourism Co., Ltd. The training bases include Zhao Gu No. 1 Mine Coal Preparation Plant, Zhao Gu No. 2 Mine Coal Preparation Plant, Guhanshan Coal Preparation Plant, Chengjiao Coal Preparation Plant, Chensilou Coal Preparation Plant, Juji Coal Preparation Plant, and Xinzhuang Coal Preparation Plant. The practice bases include Liangbei Coal Preparation Plant; Xinxiang Weida Machinery Co. Ltd.; Lixin Heavy Industry; Zhengzhou Design and Research Institute of Coal Industry Co., Ltd.; and Shenhua Ningxia Coal Industry Group Co., Ltd. In recent years, about 710 people have moved to off-campus practice bases to gain professional experience.

(3) Improve undergraduate awareness of scientific research, innovation, and innovative ability.

Undergraduates are encouraged to participate in novel experiments, student innovation and entrepreneurship training programs, scientific research practice, and extracurricular

Table 3. The detailed content of Undergraduate integrated quality credit recognition and implementation methods.

| No. | Project                           | Requirements                                                                 | Credits |
|-----|----------------------------------|------------------------------------------------------------------------------|---------|
| 1   | Research training and achievement| National project is completed or awarded.                                   | 5       |
|     |                                  | Provincial project is completed or awarded.                                  | 3       |
|     |                                  | University project is completed or awarded.                                  | 2       |
| 2   | Academic papers, newspaper articles| Main scientific and technological journals, newspapers of provincial level or above. | 5       |
|     |                                  | General journals, newspapers of university                                    | 2       |
| 3   | Patent                           | First author                                                                | 5       |
|     |                                  | First five authors                                                           | 2       |
| 4   | Discipline competition           | National award                                                               | 5       |
|     |                                  | Provincial awards                                                            | 3       |
|     |                                  | School-level reward                                                          | 2       |
| 5   | Literary competition             | National award                                                               | 5       |
|     |                                  | Provincial awards                                                            | 3       |
|     |                                  | School-level reward                                                          | 2       |
| 6   | Sports competition               | National award                                                               | 5       |
|     |                                  | Provincial awards                                                            | 3       |
|     |                                  | School-level reward                                                          | 2       |
| 7   | Test certification               | Pass the CET-6 (College English Test-6), TEM-8 (Test for English Majors-Band 8), TOEFL (The Test of English as a Foreign Language), GRE (Graduate Record Examination), IELTS (International English Language Testing System), BEC (Business English Certificate); or pass the Computer Grade Three Examination and above; or obtain senior programmer and above qualifications | 2.5     |
| 8   | Various lectures                 | Participate in various lectures organized by universities for 4 times or more | 1       |
| 9   | Social practice                  | Participate in social practice activities 4 times or more                    | 1       |
|     |                                  | Social investigation reports are approved by the college                      | 1       |
|     |                                  | Social practice activity is awarded in university level.                      | 1       |
|     |                                  | Social practice activity is awarded in provincial level.                     | 2       |
### Table 4. The awards of undergraduates.

| Number of Students | Award Level | Award Name                                                                 | Sponsoring Organization                                                                 | Year |
|--------------------|-------------|----------------------------------------------------------------------------|---------------------------------------------------------------------------------------|------|
| 1                  | Third prize | The 12th ‘Challenge Cup’ National Undergraduate Cumicular academic science and technology works of Henan Province | Communist Youth League Henan Committee                                                | 2015 |
| 8                  | Second prize| The 9th ‘Challenge Cup’ Undergraduate Cumicular academic science and technology works of HPU | HPU                                                                                  | 2015 |
| 1                  | First prize | National English Competition for College Students                          | ELT Advisory Board under the Ministry of Education                                    | 2015 |
| 1                  | Second prize| National English Competition for College Students                          | ELT Advisory Board under the Ministry of Education                                    | 2015 |
| 4                  | Third prize | National English Competition for College Students                          | ELT Advisory Board under the Ministry of Education                                    | 2015 |
| 4                  | Excellence awards | National English Competition for College Students                          | Ministry of Education of the People’s Republic of China                              | 2016 |
| 9                  | Third prize | National University Student Social Practice and Science Contest on Energy Saving & Emission Reduction | National University Student Social Practice and Science Contest on Energy Saving & Emission Reduction Committee | 2016 |
| 3                  | Second prize| The First National Higher Education of Mineral Processing Engineering Practical Work Contest | The National Chinese Mining Teaching Advisory Board under the Ministry of Education | 2016 |
| 3                  | Third prize | The First National Higher Education of Mineral Processing Engineering Practical Work Contest | The National Chinese Mining Teaching Advisory Board under the Ministry of Education | 2016 |
| 14                 | First prize | HPU Student Social Practice and Science Contest on Energy Saving & Emission Reduction | HPU                                                                                  | 2016 |
| 14                 | Second prize| HPU Student Social Practice and Science Contest on Energy Saving & Emission Reduction | HPU                                                                                  | 2016 |
| 32                 | Third prize | HPU Student Social Practice and Science Contest on Energy Saving & Emission Reduction | HPU                                                                                  | 2016 |
| 3                  | Second prize| HPU Undergraduate Mathematical Contest in Modeling                          | HPU                                                                                  | 2016 |
| 2                  | Third prize | HPU Undergraduate Mathematical Contest in Modeling                          | HPU                                                                                  | 2016 |
| 1                  | First prize | The Second National Higher Education of Mineral Processing Engineering Practical Work Contest | The National Chinese Mining Teaching Advisory Board under the Ministry of Education | 2017 |
| 2                  | Second prize| The Second National Higher Education of Mineral Processing Engineering Practical Work Contest | The National Chinese Mining Teaching Advisory Board under the Ministry of Education | 2017 |
| 2                  | Third prize | The Second National Higher Education of Mineral Processing Engineering Practical Work Contest | The National Chinese Mining Teaching Advisory Board under the Ministry of Education | 2017 |
| 2                  |            | National Undergraduate’s Platform for Innovation and Entrepreneurship Training Program | Ministry of Education of the People’s Republic of China | 2017 |
| 2                  |            | The 2th Maker competition of HPU                                           | HPU                                                                                  | 2017 |

(Continued)
| Number of Students | Award Level | Award Name                                                                 | Sponsoring Organization | Year |
|--------------------|-------------|------------------------------------------------------------------------------|-------------------------|------|
| 2                  | Third prize | Advanced Mathematics Competition                                            | HPU                     | 2017 |
| 2                  | Third prize | Advanced Mathematics Competition                                            | HPU                     | 2017 |
| 63                 |             | The 13th ‘Bubugao’ Undergraduate science and technology climbing plan       | HPU                     | 2017 |
| 3                  | Second prize| College Physics Competition                                                 | HPU                     | 2017 |
| 4                  | Third prize | College Physics Competition                                                 | HPU                     | 2017 |
| 1                  | First prize | Advanced Language Programme Design Competition                              | HPU                     | 2017 |
| 2                  | Third prize | Advanced Language Programme Design Competition                              | HPU                     | 2017 |
| 5                  | First prize | The 11th ‘Challenge Cup’ Undergraduate Cumicular academic science and technology works of HPU | HPU                     | 2017 |
| 19                 | Second prize| The 11th ‘Challenge Cup’ Undergraduate Cumicular academic science and technology works of HPU | HPU                     | 2017 |
| 22                 | Third prize | The 11th ‘Challenge Cup’ Undergradue Cumicular academic science and technology works of HPU | HPU                     | 2017 |
activities in mineral processing engineering. Students also participate in the National University Student Social Practice and Science Contest on Energy Saving and Emission Reduction, the Challenge Cup, and the Undergraduate Mathematical Contest in Modeling, among others.

The mineral processing engineering discipline cultivates students’ ability to apply professional knowledge, inspires innovation and improves innovative ability, and encourages students to forge ahead with determination.

5. Conclusions

The construction of practical undergraduate education is a long-term project that requires a systematic process. Continuous and steady reform is necessary for the development of the discipline of mineral processing engineering. Teaching reform and development achievements have established a solid foundation to cultivate high-quality talent that accords well with the needs of social and economic development.

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