Research on training top-notch applied talents of statistics based on OBE concept

Xiujie Tian, Chunlei Cheng*, Di Wu
Department of Economics, Harbin University of Commerce, Harbin 150000, China
102005@hrbcu.edu.cn

Abstract. In the context of big data, the massive amount of data generated at all levels and fields of society and economy has made the market for top-notch statistical talents increasingly demanding. However, the current training of statistics professionals is mostly curriculum-oriented. It pays more attention to theoretical knowledge while the effect of practical ability training is not good. It is teacher-centered and ignores the fundamental goal of student learning results. Reform the training model of top-notch applied talents in statistics from the perspective of OBE education concept, that is, to be oriented by industry needs, clarify the learning outcomes and graduation requirements of statistics to reform the teaching system, then cultivate top-notch statistical talents who can meet the needs of the times and social development.

1. Introduction

The concept of OBE (outcome-based education) first appeared in the education reform of the United States, which was put forward by an American scholar Spady. It is an educational concept which based on learning outcomes and bottom-up reverse designing curriculum system and training program. OBE educational concept is a reform of the traditional "teacher-centered" training mode, which emphasizes that teaching is student-centered and students are responsible for their own learning. It values learning outcomes, and emphasizes the comprehensive and coordinated development of students' quality, skills and knowledge. At present, scholars have reached a consensus on integrating talent training into OBE concept (Bo Jiang (2003), Quan Feng(2016), etc.). Some scholars have introduced OBE education concept into professional and curriculum construction specifically (Bo Wang (2019), Jianfeng Qiu (2015), etc.). However, the current OBE education concept is mainly used in chemical engineering, liberal arts and less in the application of statistics. The emphasis of OBE education concept on learning outcomes is just applicable to the cultivation of applied talents in statistics. So the cultivation of top-notch statistical talents can be integrated into the OBE education concept, and the graduation requirements can be formulated for the learning outcomes according to the current industry development needs, so as to reversely design the training mode of top-notch applied talents in statistics.

2. Graduation requirements formulation based on industry needs

The formulation of graduation requirements is the key to the formulation of training programs, but also the key to the implementation of OBE education model. It will be more suitable for the needs of the times and social needs to formulate graduation requirements to train talents based on industry needs. Follows are the specific steps.
2.1. Industry needs analysis

The cultivate of top-notch applied talents should adapt to the needs of the times and social development. In the context of big data, the social demand for data analysts, data miners, data architects and other statistics-related work is growing. Therefore, a total of 5367 recruitment information was crawled as data samples from boss direct recruitment, hunting, 51job and Zhihilian recruitment websites which use "statistics" as the key word. To begin with, 5025 data were obtained after that the sample data comb were cleaned. Then screen out the relevant positions and their corresponding job responsibilities and job requirements. Last, analyze the text using ROST text mining system: Firstly, the professional terms such as "data analysis", "data mining", "database" and function words such as "position responsibility" and "position requirement" are added to the user-defined vocabulary. Secondly, segment the data using the user-defined vocabulary and delete the function words. Finally, perform word frequency statistics based on word segmentation, and cut off the word segmentation with frequency greater than 500 (See Table.1).

| Terms | Frequency | Terms | Frequency | Terms | Frequency | Terms | Frequency |
|-------|-----------|-------|-----------|-------|-----------|-------|-----------|
| Data  | 14422     | Analysis | 12545     | Ability | 11147     | Experience | 7722     |
| 1     | 14422     | 2       | 12545     | 3       | 11147     | 4       | 7722     |
| Technology | 2729 | Computer | 2713 | Report | 2554 | Application | 2288 | Software | 2279 |
| 15     | 2729      | 16     | 2713      | 17     | 2554      | 18     | 2288     | 19     | 2279     |
| Method | 1367      | Participate | 1351     | Cooperate | 1330     | Assist | 1316    | Duty | 1302 |
| 43     | 1367      | 44     | 1351      | 45     | 1330      | 46     | 1316     | 47     | 1302     |
| Expression | 910 | Cooperation | 881 | Responsibility | 739 | Sensitive | 713 | Cooperate | 688 |
| 5     | 910       | 6     | 881       | 7     | 739       | 8     | 713      | 9     | 688      |

Table.1  Word frequency statistics of job requirements

From Table.1, we can see that in addition to data and analysis requirements, there are other ability requirements such as ability, learning, thinking and so on. Therefore, the 55 terms in Table.1 was further classified and counted, so as to summarize eight types of core abilities (see Table.2).

| Ability to analyze problems | Terms | Frequency | Proportion |
|----------------------------|-------|-----------|------------|
| Data, Analysis, Data analysis, Mining, Data mining, Clean, Collection, Data processing | 40536 | 28.94% |
| Statistical experience | Ability, Experience, Business, Project | 30389 | 21.69% |
| Software application ability | Algorithms, Models, Techniques, Computers, Application, Tools, Software, Languages, Modelling, Skills, Database, Programming | 24086 | 17.20% |
| Communication and expression ability | Communication, Report, Scheme, Statement, Write, Expression, Compilation | 11984 | 8.56% |
| Basic knowledge | Learn, Math, Knowledge, Basic, Theory | 10352 | 7.39% |
| Innovation ability | Design, Strategy, Method, Logic, Logical thinking, Thinking, Innovation | 9198 | 6.57% |
Visualize the core abilities in Table.2 in a pie chart (see Figure.1).

Figure.1 Pie chart of core abilities proportion

First of all, According to Figure.1 and Table.2, it can be seen that Statistical jobs, such as data analysts and data miners, attach the most importance to the ability to analyze problems, accounting for 28.94%, so schools should pay attention to cultivating students' statistical thinking, training students' ability to analyze and solve problems; Secondly, statistical experience accounts for 21.69%, statistical experience includes business understanding, product model, key indicators and project management ability. For college students who have not yet worked, the school can increase students' project experience through simulated practice in the form of projects; Thirdly, the proportion of software application ability is 17.20%, so students should pay attention to the improvement of software application skills during school; Finally, the sum of communication and expression ability, basic knowledge, innovation ability, teamwork cooperation ability and Professionalism accounts for more than 25%, that is, a quarter of the whole, so it can not be ignored and should be included in the graduation requirements of students.

2.2. Formulation of graduation requirements
Learning outcomes refers to the maximum ability that students can achieve after a period of study, including knowledge, skills and quality. Graduation requirements are the direct performance of learning outcomes, detailing the final results that students should achieve when they graduate, which is more intuitive and can guide the formulation of training programs. The ability characteristics of students should be reflected in the formulation of learning outcomes and graduation requirements. Select several famous universities for investigation, and consult relevant literature as the preparatory work. Then through discussions with administrators of the academic Affairs Office of the university, teachers of statistics major, students and company personnel cooperating with the university, the learning outcomes and graduation requirements of top talents are formulated in combination with the core abilities in Table 2 and training programs for statistics majors in various universities. At the same time, with the rapid development of information technology, knowledge updating is accelerating. As the Harvard Business Review put it, "The knowledge we acquire in college can only support us for five years. The solution is to develop the habit of lifelong learning". Therefore, lifelong learning should be regarded as a learning outcome (see Table.3).
Table.3  Graduation requirements for top applied talents in statistics

| Learning outcomes         | Graduation requirements                                                                 |
|---------------------------|-----------------------------------------------------------------------------------------|
| 1  Basic knowledge        | ① Grasp the professional knowledge of data acquisition, analysis, mining, collation and data visualization in the field of statistics, and have a perfect knowledge structure;  
                          | ② Establish statistical thinking.                                                        |
| 2  Use of modern tools    | ① Able to skillfully use computer and related statistical software for statistical data mining, processing and analysis, and to solve practical problems.  
                          | ② Be able to develop, select and use appropriate techniques and tools for specific problems to be solved, and have the ability to predict, simulate and solve these existing problems; |
| 3  Project management     | ① Understand the frontier and development trend of statistics specialty, and have a broad international perspective;  
                          | ② Master the implementation process of statistical projects, can correctly use statistical theory and methods, design data modeling programs, and have the ability to carry out the actual statistical project work. |
| 4  Collaborative and communication | ① Strong interpersonal skills and teamwork skills;  
                                 | ② Have good language organization ability and written expression ability, can write statistical analysis report and visualization on statistical projects, accurately and clearly elaborate statistical ideas and statistical results. |
| 5  Innovation             | ① Be able to have their own unique views and innovative thinking on the big data analysis project plan;  
                          | ② Have a strong logical thinking.                                                        |
| 6  Professionalism        | ① Have a certain sense of service and a strong sense of social responsibility;  
                          | ② To be able to consciously abide by professional ethics and norms in statistical work, with a strong sense of responsibility and high professional quality;  
                          | ③ Have certain psychological ability to resist pressure and other excellent personal ability. |
| 7  Lifelong learning       | ① In life and work, have the awareness of self-learning and develop the habit of lifelong learning;  
                          | ② Have the ability to learn independently, such as the ability to analyze and summarize in statistical practice. |

3. Suggestions on the training program of top statistical applied talents based on graduation requirements

Before the formulation of the training program, the curriculum system is divided into general education courses, professional education courses and professional practice courses, each of which includes compulsory and optional courses to ensure the personalized training of students. Under this premise, the hierarchical teaching system of cognition, experience, application and synthesis is constructed. Each level corresponds to the corresponding course module and graduation requirements (see Table.4).

Table.4  Corresponding relationship between teaching levels and learning outcomes

| Hierarchy          | Corresponding course module                                      | Learning outcomes |
|--------------------|------------------------------------------------------------------|-------------------|
| 1 Cognition level  | General education courses, Professional education courses        | 1, 5, 7           |
| 2 Experience level | Experimental course in professional practice                    | 2, 5, 6, 7        |
| 3 Application level| Comprehensive training course in professional practice          | 3, 4, 5, 6, 7     |
| 4 Synthesis level  | Internship course in professional practice                       | 1, 2, 3, 4, 5, 6, 7|

3.1. Cognition level

The cognitive level is the learning of professional theoretical knowledge and the cultivation of basic skills, and the corresponding curriculum modules are general education module and professional education module. The general education courses include the public courses such as thinking, sports and other humanities and natural disciplines, while the professional education courses include the basic courses of mathematics and the professional courses of statistics. Theoretical knowledge is the basis of practice, and the teaching of theoretical knowledge is the first and particularly important step in the teaching process, which lays the foundation for the application of knowledge.
3.2. Experience level
Experience level mainly refers to the experimental courses of professional practice, that is, the learning of computer software of statistics, such as Python, SPSS, R language and so on. On the basis of cognitive level, practical courses should be added in the process of teaching, and attention should be paid to the learning of computer language and the cultivation of software application ability.

Firstly, we can increase the experimental hours of theoretical courses, such as Matlab or R language experimental courses in mathematical analysis, probability theory and mathematical statistics.

Secondly, elective courses related to data analysis and mining can be added, such as Python, R, SPSS, Hadoop and data visualization technology, etc.

Thirdly, case teaching courses can be added to professional courses, such as case analysis using relevant course knowledge of multivariate statistical analysis and time series analysis, which can be realized on SPSS, Eviews and other software, so that students' statistical software application ability can be trained through simulation practice.

3.3. Application level
The application level is the advanced course of experience level, which corresponds to the comprehensive training course module of professional practice. Now it's time for the computer software to learn the course of the project. And the course focus is no longer the learning results, but more attention to the students' learning process. Students can understand professional knowledge, exercise practical ability and cultivate individual ability and teamwork ability in project practice.

The application level also includes subject skills competition, professional-related vocational skills examination, graduation thesis design and so on. Teachers should actively encourage students to participate in subject skills competitions, such as statistical modeling contest, SAS data analysis contest, market research contest, etc. At the same time, teachers can also guide students to participate in data analysts and other professional skills related to statistics. In addition, for graduation thesis, the college can invite relevant experts of enterprise data analysis to give lectures to guide students to conduct research on actual data analysis projects of enterprises, so as to make the thesis topic closer to life and career reality.

3.4. Synthesis level
Synthesis level refers to the internship course of professional practice, which means that students go out of the classroom and campus and face the society. Schools can cooperate with enterprises for a long time. Schools recommend top talents to enter enterprise for internship during weekends and holidays, in which students can be familiar with the implementation process of statistical projects and learn to deal with real projects. In this level, tutors should communicate with enterprises in time, so as to form a double-tutor system which combines college tutors who are proficient in professional theory with enterprise tutors who have rich practical experience. At the same time, it also pays attention to the cultivation of students' software application ability, project management ability, collaborative and communication ability and Professionalism.

4. Formulation of Evaluation System
One of the important principles of OBE educational concept is continuous improvement, that is, to establish an effective evaluation system and form a regular evaluation. In this system, we can promote construction and reform by evaluation, thus forming a dynamic cycle of evaluation-feedback-improvement-evaluation, and realizing the closed loop of education mode. The evaluation system is considered from two perspectives of student achievement assessment and questionnaire survey. For the assessment of students' achievements, we should weaken the attention to the "digital achievements" on the paper. The two assessment methods of process assessment and diversification assessment can be integrated. It is conducive to the formulation of personalized training programs by tracking and recording students' basic information, students' phased achievements, personal strengths and ability performance, etc. It ensures that the learning results of students can be reflected to the greatest extent
by diversified assessment methods, such as the combination of professional basic theoretical knowledge and practical ability. For the questionnaire survey, we should investigate the students, including graduates, teachers, education experts in the field of statistics, enterprises and institutions, to understand the needs of the society in time. At the same time, the evaluation table is designed to evaluate the training program from four aspects, namely, training background, input, process and result, so as to guide the improvement of the training program in colleges and universities.

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