Research on Curriculum Reform of Industrial Training Center Based on PDCA Cycle

Yige Zhu, Xiqin Geng, and Qing Zhang

***Abstract*—Because of the rapid development of the modern society, the demand for the high educated students is becoming more and more urgent. At the same time, these graduates are also requested to have higher levels to suit the working conditions. Industrial Training is one of the most important series courses and play an irreplaceable role in cultivating compound talents. This paper use PDCA to discuss the course system of the Industrial Training Center in NUAA. With the use of PDCA, we redesign a new system for the whole center. When designing the new system, SOP and BSC are also used to full the whole system. It will provide a new way to the development of the Industrial Training Center.**

***Index Terms*—PDCA, industrial training, SOP, BSC.**

I. Introduction

A. Industrial Training

Industrial training center is an important teaching base for students to carry out comprehensive industrial technology education in the process of college education. The industrial training center of NUAA is a basic teaching unit directly responsible for the whole school's industrial training teaching task. Nowadays, the new generation of college students is more independent and has high sense of self-identification. They want to participate more in the whole procedure of teaching, which means the traditional teaching methods and evaluation patterns are no longer desirable. Under this situation, it is urgent to design a new curriculum model which is more suitable for the new generation of students.

Zheng Zhaoxia, Ma Hongbing studied the reform of engineering training and teaching based on the cultivation of engineering consciousness under the background of the big industrial area [1]; Zhou Wei used Guizhou University as an example to analyze the problems existing in the engineering training of Guizhou University. And correspondingly put forward the solution of modular modularization of the course, and discuss it [2]; Qian Jun, based on the teaching management of higher engineering colleges, put forward a design scheme of engineering training and teaching management system based on ASP, which is engineering training. The center has built an information platform, which greatly improved the management efficiency [3]; Jiang Haiyan, Wang Guochao and so on proposed to build a DNC numerical control training platform for numerical control training to improve learning efficiency [4]; Liu Lijuan, Ma Xiaoxin proposed to combine the Internet Adding thoughts, giving play to students' subjective initiative and cultivating students' innovative ability [5]; Duan Chunzheng, Yang Chun et al. proposed the project-driven concept of introducing competition form into engineering raining [6]; Zhang Xiaoyu, Li Ping The change of the engineering training system in the new era, and proposed that the current university engineering training must be from closed to open, from passive to The three types of dynamics, from cognitive to creative [7]; Zheng Zhaoxia, Xiong Xianyun proposed to divide the curriculum of the engineering training center into compulsory courses and elective courses, using a combination of two courses to improve training. Flexibility [8].

At present, the training of industrial training center mainly takes classes and colleges as teaching units. Because of the different training objectives, the training time varies from one week to four weeks. According to the limitation of the number of teachers and machines in the center, rotate according to the class during the training period. Although such a situation can enable students to achieve the purpose of training, and avoid the situation where students or teachers are too idle due to air rotation in the case of seasoned scheduling, there are still many defects. It is inevitable to encounter some thorny problems in the process of students' training and teachers' teaching. For example, the training of junior students is in conflict with English classes. Some majors that require four-week training appear to be very tight in the course arrangement of a certain semester in order to reserve enough time for class scheduling.

In the process of teaching, it is more dependent on teachers' own experience and the obscure teaching outline in the textbook. Most of the courses are conducted by students after the teacher explains and demonstrates for only once. At this point, most students will choose to let go of their mistakes and finally fail to produce the finished products that meet the requirements of the course. A small number of students will ask the teacher questions continuously in the process of operation, while because of the large number of students, teachers can't help all the students in time.

Therefore, the teaching methods of the entire engineering training center are in urgent need of improvement. In the process of improvement, we consider the use of standard operating procedures to optimize the operation process, but it is not enough to optimize the operation process. The optimization of the whole process is Better improvement,

Manuscript received March 20, 2019; revised May 29, 2019.

Yige Zhu is with the College of Economics and Management, Nanjing University of Aeronautics and Astronautics, Nanjing, Jiangsu, China (e-mail: zhuyige_nuaa@163.com).

Xiqin Geng was with Industrial Training Center, Nanjing University of Aeronautics and Astronautics, Nanjing, Jiangsu, China (e-mail: etcgengxq@nuaa.edu.cn).

Qing Zhang is with the College of Economics and Management, Nanjing University of Aeronautics and Astronautics, Nanjing, Jiangsu, China and Industrial Training Center, Nanjing University of Aeronautics and Astronautics, Nanjing, Jiangsu, China (e-mail: karlnuaa@nuaa.edu.cn).

doi: 10.18178/ijiet.2019.9.8.1268

constructing a new process for the entire engineering training center is the key to solving the problem.

B. PDCA in Industrial Training

The PDCA [9] cycle was first proposed by Dr. Huh Hart, a US quality management expert. It was adopted, promoted, and popularized by Deming, so it is also called Dai Minghuan. The ideological basis and methodological basis for total quality management is the PDCA cycle. In the quality management activities, it is required to follow the plan, plan implementation, check the implementation effect, and then incorporate the success into the standard, and leave the unsuccessful things to the next cycle. This working method is the basic method of quality management and the general law of all aspects of enterprise management.

In addition to being widely used in manufacturing, PDCA has been widely used in other fields outside the manufacturing industry. Introducing PDCA into the teaching process of the industrial training center is a new application of the old method.

The PDCA is divided into four stages. First, it needs to be planned before the optimization and improvement of the whole process. Plan is to identify the target and find the solution direction of the problem. In the industrial training center, the target identification is the demand identification. After identifying the needs of enterprises, colleges, and students for engineering training, it is necessary to improve and optimize according to different categories; secondly, do, optimize the process, improve the process under the established plan, and implement the new plan. Improve the old method; check, the focus of check is on feedback and improvement. For the industrial training center, the inspection is the assessment of the teacher and the student. According to the assessment results, the feedback is corrected and optimized, and then corrected and act. A Deming ring down, improve the problem, and then find new problems in the entire curriculum system, and then improve, the key to the PDCA cycle is that there are small loops under the big loop, interlocking, continuous improvement, forming a dynamic forward Good situation.

II. Target Identification (Plan)

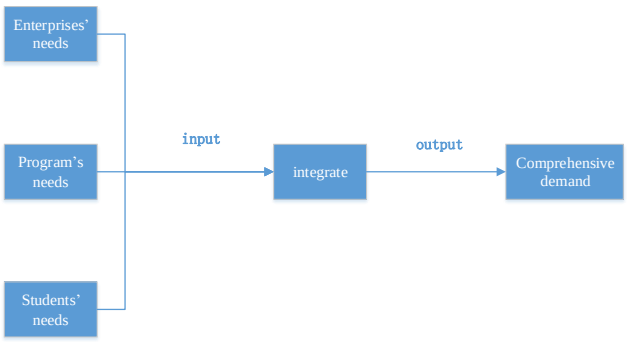


Fig. 1. Needs from different aspects.

A. Enterprises' Needs

First, we should consider the needs of business users. After the training of colleges, most students will work in various positions in the society. Therefore, when training students, we must first consider the needs of the society and enterprises. When considering the needs of enterprises, we can cooperate with enterprises to hold joint school and enterprise training, corporate symposium, face-to-face communication, etc. to understand the needs of enterprises and make plans according to the needs of enterprises.

B. Program's Needs

The second point is to consider the needs of the college's student development program. Obviously, different majors and different colleges have different needs for the student industrial training curriculum. The profession can be divided into several categories, such as machinery, near-mechanical, electrician, science, humanities and social sciences. Different categories of majors need different arrangements so identifying the needs of different colleges are also an integral part of planning.

C. Students' Needs

Finally, based on the courses adjusted according to the requirements of enterprises and colleges, the courses can be adjusted according to the students' interests. The student's needs are mainly appeared in the form of interest courses. On the basis of the compulsory courses, the elective courses are set up by the students to supplement the course content to achieve the most perfect purpose.

As shown in Fig. 1, we can figure out different needs from different aspects.

III. Process Improvement (Do)

A. Design Course SOP

The first step to standardization is to establish SOPs which are mainly for engineering practice classes. The design and fabrication of SOP is a complex and time-consuming process requiring validation and tracking. It needs to be fabricated using a variety of industrial engineering tools. In this paper, how to design SOP is not our focus, so this section does not explain too much about this.

B. Design Course System

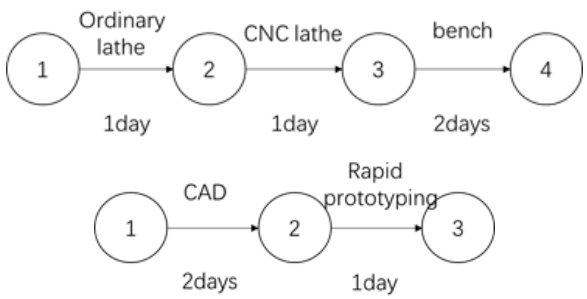
At present, the courses of industrial training center can be divided into four parts: engineering design, engineering practice, engineering management and integrated innovation. The four parts of the course contain many kinds respectively. From the logic of the course, the practice course is the foundation of all the courses. The practice course includes the teaching of engineering training theory and the practical operation course; The design course is the re-creation of the course after understanding the technology, and the design thinking is also an indispensable part in the engineering training; Engineering management is a new cognition of industrial training in engineering colleges on the basis of learning operation practice. Understanding practice from the perspective of management is of great benefit to subsequent career development; Finally, comprehensive innovation course is the cultivation of comprehensive ability, which is a comprehensive exercise and improvement of one's own ability on the basis of finishing all the previous courses.

After having such a preliminary course, the course is divided into three levels. The first level is the knowledge level, which is mainly the theoretical teaching part. At this level, the teacher explains the theoretical part of engineering manufacturing, so that the students can master the general process of mechanical manufacturing, and accurately describe the basic concept, terminology and common sense of mechanical engineering. The second level is the ability level, which requires students to participate in the actual operation of engineering manufacturing, master the general technology of engineering manufacturing through on-site demonstration teaching by teachers, and be able to use common innovative methods. The third level is the literacy level, which is the comprehensive use of the previous two levels of learning content. This layer mainly relies on the way of self-learning by students and uses project learning to give students more space and sufficient time to exert themselves. This level adopts the project-based learning method. After the students finish the project, the teacher will check and accept the project according to the situation.

Considering that different majors have different demands for industrial training courses. Therefore, all courses cannot be generalized, and some courses need to be screened and taught in batches. After screening and comparison, it is not difficult to find that some of these courses exist as compulsory subjects which means all students need to learn, while some courses are tailored to specific professional learning, only a little part of students need to be taught. Therefore, we only need to sort out these courses and rearrange the course system by combining optional courses and compulsory courses.

On the basis of this course system, we can introduce the course SOP designed in the first section into this course system, so as to achieve the purpose of higher efficiency. When using SOP to standardize teaching process, we can also use the idea of process management in SOP to standardize the curriculum arrangement and introduce the concept of curriculum chain to standardize the curriculum arrangement. The use of the curriculum chain can also minimize logical errors in scheduling courses. At the same time, the curriculum chain should also have some flexibility, and can be flexibly combined according to different professional training objectives.

Here are some schematics of the curriculum chain, as shown in Fig. 2, there is a close correlation between these courses. When arranging practical courses, we can add other courses flexibly according to the specific teaching time on the basis of these established course chains, which can effectively improve the efficiency of course scheduling and guarantee the pertinence of courses.



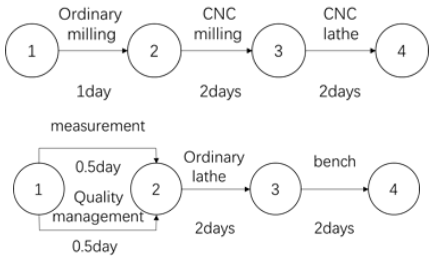


Fig. 2. Curriculum chain.

On the basis of introducing the curriculum chain, we can get a more perfect curriculum system diagram as shown in Fig. 3:

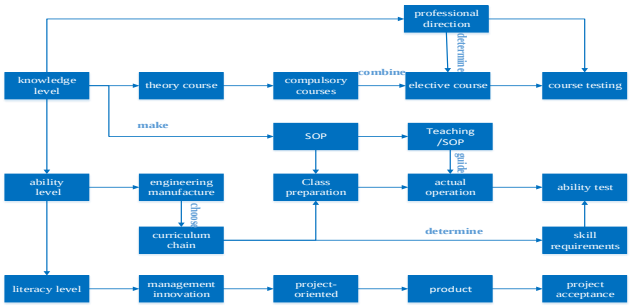


Fig. 3. Curriculum system.

C. Design Information Platform

The above curriculum design framework requires the use of Internet tools in the course selection and teaching process. Therefore, the information construction of industrial training center is also indispensable. We can build the information system platform [10] of the engineering training center on the basis of this course framework and design a mobile app which can collect lectures, preview before class, guide during class, and evaluate after class in time.

The information system should include three aspects, the knowledge level needs to design the course selection system and the test system. The ability level should include course chain selection, course preview, pilot video learning with SOP, practical operation and final acceptance. The literacy level includes project campaign, theoretical supplement and project acceptance. The course framework design combined with information platform is shown in the Fig. 4:

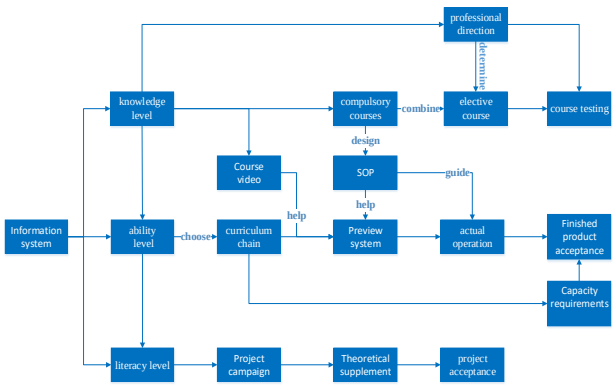


Fig. 4. Information system.

IV. Assessment (Check)

A. Teachers Performance Appraisal

The construction of teaching staff and performance evaluation has always been one of the biggest problems in universities. How to establish an effective and fair assessment system to balance the energy of college teachers in teaching and scientific research work has always been a hot research issue. As an important teaching unit in the education system of universities, the Industrial Training Center has both the problems of the general teaching unit and its own particularities, which means we can't simply take it as an easy problem. This article intends to use Balanced Score Card (BSC) [11]-[15] to research the performance evaluation of teaching staff in modern industrial training and change the old evaluation which only pays attention to the result into an entirely new way. At the same time, using BSC can also combine the performance evaluation with the future development strategy of industrial training, which means a new model of future development of industrial training can be designed while improving it.

The design of the performance appraisal of the industrial training center faculty using the BSC is as follows:

Financial dimension: In this dimension, we use class hours to substitute for the financial. This dimension is the result index of BSC. This dimension mainly evaluates the number of hours took by teachers and the number of projects directed by them. The number of hours includes theoretical and practical courses, in which the theoretical and practical courses are set up by different weight ratios according to the different nature and length of the course. The number of projects is what framework has in the third level. The workload each teacher took is conducted as one of the basic elements of assessment.

Customer dimension: Customer dimension is the result index of BSC. The customers of industrial training are students. In this dimension, we set up a student satisfaction index and take students' feeling into account. When they finished their classes, they are requested to fill a form and express their feelings of the teachers. Their attitude should be taken into the evaluation system. In addition, the project acceptance rate issued by the teachers is also considered as one of the indexes. In the end, teachers were given a comprehensive score based on the project acceptance rate and the completion rate of students.

Internal process dimension: The internal process dimension is the driving index of BSC. This dimension evaluates the teaching staff from the management aspect. It evaluates teachers' effect on the completion of the curriculum process, the efficiency of daily work and the optimization of the whole organization process. This index takes the future development strategy as the core of the whole evaluation system. The main judgement of the assessment is whether the behavior is helpful to the implementation of the new curriculum system, whether it helps to optimize the internal process, etc.

Learning and development dimension: Learning growth dimension is the driving index of BSC. This dimension contains two levels, the first level is the learning of the teaching staff itself. It contains their learning consciousness. The certificates they get and the papers they publish can be bonus points. The second one refers to the learning and development of the whole industrial training center, such as the construction of the information system, the constantly updated educational model, and the continuous development of a better way in education.

The four dimensions above put forward how to use the Balanced Scorecard to assess the teacher performance in industrial training. We design the performance evaluation indicator chart as follows based on the above analysis which can be seen as Fig. 5:

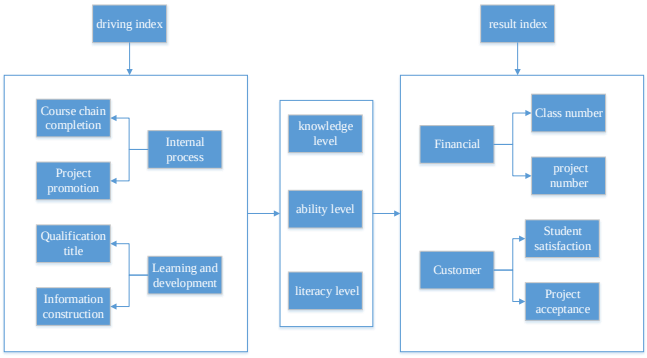


Fig. 5. Performance evaluation system based on BSC.

B. Students Achievement Appraisal

Corresponding to the new curriculum system, the appraisal of students can be divided into three categories: knowledge level, ability level and literacy level.

The appraisal of the knowledge level is mainly for the assessment of theoretical learning knowledge. This part can continue to use the traditional examination methods to assess students, and judge the students' mastery of theoretical knowledge through the test scores; The second is the assessment of the ability level. The ability level mainly examines the students' practical ability. This part of the assessment is relatively flexible, as long as the student can operate correctly according to the SOP and master the general methods of engineering training could they have a good result; the last level is an examination of the students' comprehensive quality. The project-based learning form is adopted for this level. Therefore, in the final assessment, the degree of student participation, the degree of project completion, and the complexity of the project itself will be considered to evaluate the learning outcomes of students.

V. Correct (Act)

The final implementation should have reflected and rectified the entire process based on the previous inspections.

1) Standardization, standardizations are the driving force of the whole system. Without standardization, the system will not progress or even decline. Standardized measures that have been proved should be standardized as SOP. will bring development into working standards for future implementation and promotion for future implementation and promotion.
2) Summary of the problem and deal with the remaining issues. A PDCA cycle cannot solve all the problems, and the remaining problems will be automatically transferred to the next PDCA cycle, so that the spiral rises. The processing phase is the key to the PDCA cycle. Because the processing stage is the stage of solving problems, summing up experience and learning lessons,

the focus of this stage is also on the revision of standards, including technical standards and management systems. Without standardization and institutionalization, it is impossible to rotate the PDCA cycle forward.

It should be noted that the PDCA cycle does not cycle at the same level. Once every cycle, it solves some problems and achieves some results. The work goes further and the level advances one step. Every time a PDCA cycle is passed, it is necessary to summarize and propose new targets, and then carry out the second PDCA cycle to make the wheels of quality control roll forward. Each time the PDCA is cycled, the quality level and governance level go further. Through continuous improvement of the loop, we can correct problems in the entire system.

VI. Conclusions

This paper adopts the idea of PDCA cycle, and carries out a preliminary design of the curriculum system of the whole industrial training center.

First of all, according to different Party A's needs for the curriculum, comprehensively consider the plan for the whole improvement, and then combine some methods of the Standard Operating Procedure (SOP) to optimize the curriculum process of the entire center and design a new curriculum system. Secondly, assess the teachers' and students' achievements to check the new system. Finally, correct the improvement measures proposed above according to the performance of the assessment.

One of the great advantages of the PDCA cycle is that it can further improve the improvement effect according to the results of each assessment, thus promoting the development of the entire system and driving the continuous advancement of the entire system. Therefore, in the later stage, we need to continue to further improve and optimize the entire system, so that the entire cycle can be organically moved.

References

[1] Z. X. Zheng and H. B. Ma, "Engineering training teaching reform guided by engineering awareness in the age of big industry," *China Educational Technology & Equipment*, 2017, no. 22, pp. 147-149.

[2] W. Zhou, "Research on modular unit teaching of engineering training courses in colleges and universities," Journal of Experimental Science and Technology, 2017, vol. 15, no. 06, pp. 163-167.

[3] J. Qian, "Design and implementation of engineering training educational administration system," *Information and Computer (Theoretical Edition)*, 2011, no. 02, p. 61.

[4] H. Y. Jiang *et al*., "Reform and practice of numerical control training in engineering training," *Education and Teaching Forum*, 2018, no. 10, pp. 134-135.

[5] L. J. Liu *et al*., "Research on engineering training teaching reform based on "Internet +"[J]," *Wireless Interconnect Technology*, 2017, no. 14, pp. 29-30.

[6] C. Z. Duan *et al*., "Research and practice of teaching mode of mechanical international class engineering training course driven by innovation projects," *Education and Teaching Forum*, 2017, no. 23, pp. 148-150.

[7] X. Y. Zhang *et al*., "The reform of college students' engineering training system in the new era," *Journal of North China Institute of Science and Technology*, 2017, vol. 14, no. 05, pp. 112-116.

[8] Z. X. Zheng and X. Y. Xiong, "Research and practice of engineering training teaching reform with project as carrier," *Journal of Experimental Science and Technology*, 2018, vol. 16, no. 01, pp. 79-81.

[9] M.-M. Ren *et al*., "The application of PDCA cycle management in project management," *International Conference on Computer Science and Applications (CSA)*, pp. 268-272.

[10] Z. F. Wang *et al*., "Analysis of the model of teaching management informationization in secondary colleges in colleges and universities," *Education Theory and Practice*, 2016, vol. 36, no. 27, pp. 15-17.

[11] J. Liu, "Application of BSC-KPI assessment method in performance evaluation of marketing department [A]," *China Tobacco Society 2016 Excellent Paper Collection - Tobacco Economy and Management Theme [C]*, 2016, vol. 7.

[12] S. Z. Li and W. Liu, "Analysis of performance evaluation of commercial banks based on balanced scorecard," *Research on Financial and Economic Issues*, 2010, no. 04, pp. 76-79.

[13] Q. Y. Wu, "On the characteristics and functions of balanced scorecard in public sector performance management," 2017, no. 08, pp. 124-127.

[14] B. H. Zhang, "Design of performance evaluation indicators for grassroots management personnel based on balanced scorecard," *Shaanxi Education (High Education)*, 2017, no. 11, pp. 45+47.

[15] Y. S. Qiu, "Performance management of college faculty based on balanced scorecard," *Journal of Suzhou University (Philosophy and Social Sciences)*, 2008, vol. 29, no. 06, pp. 113-115.

Copyright © 2019 by the authors. This is an open access article distributed under the Creative Commons Attribution License which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited (CC BY 4.0).

Yige Zhu was born in Luoyang, Henan province, China in September 1995. She is graduate student of College of Economics and Management, Nanjing University of Aeronautics and Astronautics. Her major is in industrial engineering and research orientation is production operation and management.

She published papers: Balanced Scorecard (BSC) in evaluating the teaching staff of modern industrial training, A Research on Curriculum Optimization of NUAA Industrial Training Center Based on SOP.

Xiqin Geng was born in Jingjiang, Jiangsu province, China in 1980. She obtained her master degree in mechanical engineering in Nanjing University of Aeronautics and Astronautics in 2013. Her research interests include CAD/CAM.

She published papers: Design of NC Machining Simulation System and Its Application in Industrial Training, Exploration of CAD Bilingual Teaching Mode in Industrial Training. She is also involved in the preparation of the book Computer Aided Design and Training.

Qing Zhang was born in October 1971 in Guizhou province, China. He obtained his PhD degree in management science from Nanjing University of Astronautics and Aeronautics in 2008.

He has published several papers, including [1] Zhang Z, Zhang Q, Liu Z, Zheng X. Static and dynamic pricing strategies in a closed-loop supply chain with reference quality effects[J]. Sustainability, 2018, 10(1): 157. [2] Leizhou Zhao, Qing Zhang. Coordinating of O2O Fresh Agricultural Products Supply Chain with Asymmetric Information When Disturbance Occur Online. Journal of Management and Sustainability. Vol.7, No.4, 2017.12. [3] Leizhou Zhao, Qing Zhang. Coordinating O2O Fresh Agricultural Supply Chain Considering Information Asymmetry when Disruption Occurs offline. Proceedings of 2017 IEEE GSIS International Conference, 2017, Sweden. His research interests include logistics and supply chain management.