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Research and implementation of management information system for Engineering Training Center in university

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Abstract
Engineering Training Center (ETC) in university is based on engineering training and teaching, supplemented by production, which is different from the general factory. So, existing commercial software systems cannot be directly applied to ETC. This paper presents a management information system (MIS) for Engineering Training Center in university, named ETC-MIS. The proposed ETC-MIS includes the managements of routine training teaching and external processing tasks. Firstly, the information needs of ETC were analyzed in depth. Then, the whole data flow model of system was discussed. Finally, the module function of ETC-MIS was designed. Practical application indicates that ETC-MIS significantly improves the efficiency of ETC in university.

Keywords Engineering Training Center (ETC) · Management information system (MIS) · Teaching management · Course scheduling · Role mapping

1 Introduction

Engineering training is a new educational idea proposed under the background of large engineering and large manufacturing in china. Engineering training is an important educational session in developing the practical ability and innovation consciousness of student due to its general basic engineering practice such as the engineering practice education, the understanding of industrial manufacturing and the experience of industrial culture for students [1]. Engineering Training Center (ETC) is the basic platform for implementing engineering practical teaching [2]. In China, nearly all comprehensive universities have built ETC with the characteristics of bigger scale, more comprehensive categories, higher level teachers and more advanced equipment.

At present, ETC has become a practice education base with the largest number of qualified teachers and students. Overall, most ETC have been some development in the hardware. However, field researches of dozens of domestic universities show that there are several outstanding issues, especially in management.

In recent years, information technology has been increasingly used in the industry. The advanced manufacturing theory and technology, especially digital manufacture and intelligent manufacturing have been developed. Both "Industry 4.0" original of German and "Integrate of Informatization and industrialization" proposed by China focus on fully applying information technology to realize transformation and upgrading traditional industries.

In order to improve quality and effectiveness, and to quicken the fusion between information technology and manufacturing, China published "China Manufacturing 2025" in March, 2015. Its aim is to propel intelligent manufacturing and to raise comprehensive integration of information and industrialization. The main line of "Made in China 2025" is the digital, network and intelligent manufacturing, which proposes a new requirement not only for the manufacturing transition, but also for the personnel training.

However, the current engineering training in most universities does not pay enough attention to the information technology involved in production management information system. The course of engineering training also lacks contents related to advance manufacturing technology and

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production management. Compared with "metalworking practice" that is to learn and master certain basic skills, Engineering Training Center has richer connotation and broader extension instead of the simple replacement of name, reflecting a deeper time background. ETC should provides an environment of production and operation with a high degree of authenticity and also provide an advanced and innovative platform of engineering practice. furthermore, engineering training must make students acknowledge some concepts such as digital manufacturing, flexible manufacturing, technology integration, electromechanical integration control and the development of modern design and manufacture.

Regrettably, in China most of ETCs generally focus on the construction of hardware while lacks of necessary information management system. Engineering training projects or courses lacks of information technology, production management and project management, and so on. ETC in university should be a modern and advanced factory involving advanced equipment, advanced management and advanced teaching content. However, on the Management, most of ETC cannot reach the level of modern enterprise.

This paper is aimed at the current needs of MIS of ETC in China, and studies the key technology of ETC-MIS to meet the needs of Engineering Training Center production, teaching and training. Finally, develop an advanced and practical MIS for colleges and universities ETC in China.

2 Literature review

With the rapid expansion of the ETC, the traditional management methods seriously hindered their development and it was necessary to use advanced MIS to improve its management level. The MIS of ETC should include instructional monitoring, teaching management, resource management, performance assessment and management and so on.

Shuo et al. put up a website for ETC in colleges and universities, the website can help to achieve information education management and provide better practice condition for students [3]. but the website of ETC is only a website, it only include three functions: (1) online score management; (2) online course selection; (3) interactive platform for teachers and students.

Zhu et al. [4] analyzed the necessity of information construction for ETC, and proposes some ways and construction procedures to achieve the network of engineering training. The terminal of laboratories, offices and factories workshop was connected adopting the star structure by network. Aiming at the management difficulty of ETC, Dou et al. [5] studied the management system of ETC based on ZigBee, improving work efficiency and equipment utilization and raising the level of laboratory management. Wang et al. [6] proposed the specific content, scheme and basic function of the information construction in ETC. Qian et al. [7] developed a website of ETC and designed corresponding educational administration system. The information networking construction provides the industrial training practice teaching with the optimized practice teaching resources, provides the simple effective laboratory management and the teaching method for the teacher, and makes the student have the most convenient simple and direct communication with the industrial training, to compliment the practice teaching better.

Yang et al. [8] researched the construction model and contents of the information management platform for the Engineering Training Center at College. And a practical system has been put into practice.

According to teaching management system of the higher education, Gui et al. [9] researched a teaching management system design way for ETC based on RFID. Cao

To meet the need of engineering practice training teaching, make full of the current teaching resource and reduce the burden of teachers, Hu et al. [10] proposed a network of engineering practice training examination system.

According to practice teaching needs, Sun et al. [11] design an internship production plant information management system. Through the system to machine tools, students, rough three main factor of production science together, science uses modern means of information management, the complicated routine management become simple.

Zhang et al. [12] analyzed and optimized the original workflow of warehouse, what more, the practical problem that ETC faced with was analyzed, and course scheduling mathematic model was established.

The reasonable and effective management system and operation mode is very important to ETC. Teaching quality is the guarantee of engineering training, teaching quality, effectiveness of engineering training is key to cultivate students' innovative spirit and ability. Engineering training should cultivate students' modern engineering capabilities, including full use of various resources, construction of scientific engineering training system [13].

Modern factories use information systems to improve production management and efficiency. The management information system in the factory has become increasingly important. These MIS are based on the operation of enterprises as the core, focusing on improving production efficiency and reduce costs. ETC is based on engineering training and teaching, supplemented by production, which is different from the general factory. So, these systems cannot be directly applied to ETC.

Manufacturing execution system (MES) is an information management system for workshop, which effectively improve production management level and timely delivery. MES are used to track and document the transformation of raw materials to goods. Manufacturing execution system pro-

vides information that helps manufacturing decision makers understand how current conditions on the plant floor can be optimized to improve production output. Manufacturing execution system create flawless manufacturing processes and provide real-time feedback of requirement changes, and provide information at a single source. Manufacturing execution system is in the upper information system and the underlying control system executive layer. In recent years, manufacturing execution system has been widely used, and achieved good results. Therefore, manufacturing execution system should be an important part of engineering training [14].

Currently, only a few universities applied MIS into engineering practice training. Tsinghua University designed and operated mixed-model assembly experiment by (MES) system equipped with the assembly line [15], which provides a reference for other universities to apply mixed production experimental design based MES. However, some areas still needed to be improved. For example, The MIS based on MES concerned with the stage of production and operation, and overemphasize the function of MES. The degree of automation system is often overshadowed the internal relations of knowledge, reduce the degree of intervention of students, so that the experiment too much emphasis on software.

Wang et al. [15] combined with a practical application of MES and training objective of industrial engineering build a comprehensive experimental platform based on MES.

Yang et al. [16] set up digital workshop experiment course based on MES. The course is stand-alone operation, did not is network. This MIS is included storeroom management, dispatching workshop and completed work, operational planning and so on. However, the experiment only provides a simulated environment, in which students only do standalone operation. It is Just a simulation environment.

Yan and Jin-hang [17] introduction a discrete manufacturing execution system for education. There were eight modules in the proposed system, including system management , product design, process planning, planning and scheduling, production processing, quality inspection, logistics distribution, and warehouse management. The students could simulate the discrete production process by using of this system, and play a variety of roles to complete different operation processes.

In fact, ETC should provide a real factory production environment, and MIS should implement the functions of daily teaching management. On the other hand, it also realizes the function of production information management, which is similar to general factory. In addition, MIS should provide practical operation for students to form a real production management information system, and also provide training content that is connected with management information systems. That is to say, MIS of ETC is also used as an engineering training content, its one or serial function module, can enable students to truly operational information systems. The MIS applied in ETC to make students experience real digital factory environment, which makes students access to advanced technology management and also trains their comprehensive ability to solve practical engineering problems.

This paper is aimed at the current needs of MIS of ETC in China, and studies the key technology of ETC-MIS to meet the needs of Engineering Training Center, especially the management of production, teaching and training. Then, develop an advanced and practical MIS for universities ETC in China.

3 System function and its design

Digital manufacturing system of ETC mainly considers machine, electronic, computer, and management integration as a core and it is a comprehensive training system which integrates the engineering design, manufacture, management, and innovation, as shown in Fig. 1. The aim is to establish a practice environment that is similar to a digitalized factory and build a manufacturing system which is similar to the industrialized production. From the teaching point of view, the system should be adequately embodies the participation of students and achieves the seamless joint between engineering training education and industry. It makes the Engineering Training Center become a real factory and provides an advanced practice platform for students.

- ETC-MIS provides an information management covering the whole production process of ETC. It includes the design, manufacturing, delivery, articles being processed, storage, order, and producing plan for Engineering Training Center which can realize the product lifecycle management.
- ETC-MIS realizes the whole process supervision on engineering training teaching. For example, course scheduling, mission distribution, examination, and score management, and so on.

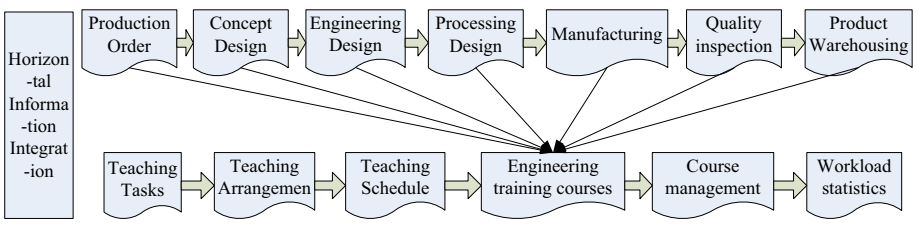

Fig. 1 Horizontal information integration illustration of ETC

- ETC-MIS integrated the existed MIS of university, For example, CAD, CAM, PDM and teaching MIS, and so on.

The proposed system covering the teaching and production management, on the other hand, the system itself is a teaching system, students can use the system to learn and master the management information system operation.

3.1 The whole data flow model of system

The object of the MIS of ETC in university mainly includes two parts, teaching and manufacturing, which needs to cover the managements of routine teaching and order manufacturing. Using the information management system can improve the management level of the center and realize the information sharing, and thus improve the rate of equipment utilization. First of all, The system must ensure the implementation of teaching, and then takes into account the production of external orders.

On the basis of analyzing the processes of teaching and order manufacturing in Engineering Training Center, ETC-MIS system can be divided into fourteen processing units: system integration, basic information management, system management, engineering training course scheduling, document management, score examination and management, order management, store management, operational plan design and management, job allocation and management, equipment management, production schedule monitoring, board information management, and the tracing and management of articles being processed. The data streaming model of system is given in Fig. 2. As indicated, the bills of material (BOM) are relatively simple because these parts manufactured by the foreign processing of ETC and the processing of engineering training are relatively simple. Therefore, there is no module related to the BOM management in ETC-MIS.

System integration module is mainly from other information systems to obtain basic data information. For example, from manufacturing data collection and control (MDC) acquisition of CNC machine tools and other smart devices (AGV) work and operational status data, and to get teaching plan and student information from teaching MIS. Kanban is Japanese for “visual signal” or “card.” Toyota line-workers used a kanban to signal steps in their manufacturing process. Shop Kanban mainly display some exceptional information, progress information, scheduling information.

3.2 System function module

According to the management requirements of ETC and system design principles, the proposed ETC-MIS system is divided into the following fifteen function modules (shown as Fig. 3).

3.2.1 System management module

This module realizes the day-to-day management of the system, maintained data consistency and integrity of the whole system, and provided support for system administrators. System administrators can add, remove system users and assign the appropriate permissions for the user including teachers, students, workers, managers, and so on.

Users of ETC-MIS not only have permissions of general information system, but also teachers and students even have dynamic permissions. As the adviser of the class for project training, he or she has the permissions of achievement evaluation. For students, the permissions will gradually be expanded with increasing grade because the system provides students practical experience and the function of information system operation.

The actual operation of students will be realized in a virtual system environment, which has no influence on the actual system. This depends on the technology of role mapping and data mapping to achieve. As shown in Fig. 4,

In the ETC-MIS system, one part is the management of real production and teaching activities, and the other part is the function of students to practice operation and management of information systems. Students enter the system in a certain system role, the role is really the role of mapping, and the results of the operation is also stored in the system, but in a separate database in the form of mapping, and the results of student operations do not enter the actual the production database, does not work on the actual production. so, in this way, ETC-MIS realizes the function of production information management, which is similar to general factory. on the other hand, the proposed system is also used as an engineering training content, can enable students to truly operational information systems. The ETC-MIS applied to make students experience real digital factory environment, which makes students access to advanced technology management and also trains their comprehensive ability to solve practical engineering problems.

3.2.2 Basic data management module

This module includes calendars, workshops calendar, information management, equipment information and items of basic information, which provides the basic data for the whole system. This system also has the function of material code.

’Materials’ is the general terms of all indispensable scheduled into production plan and teaching arrangement, which is not just raw materials or spare parts, also including rough products, semi-finished products, finished products, outsourcing, even tools, personal protective equipment, energy and so on. Material coding must satisfy the expandability and stability.

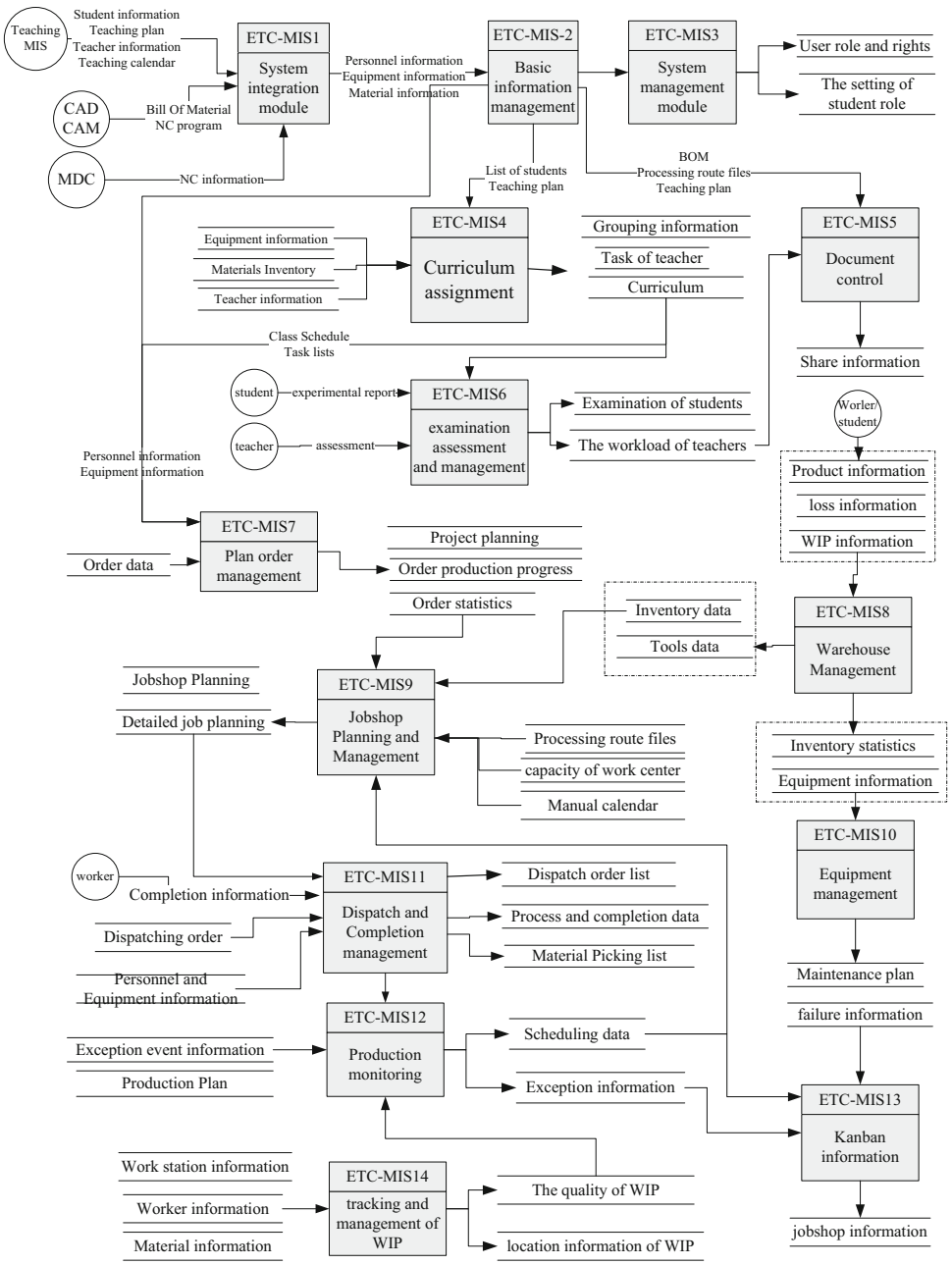

Fig. 2 The data flow diagram of ETC-MIS

3.2.3 System integration module

System integration module. ETC system integrated with the teaching MIS of schools to access to the list of practical training students and the information such as the teaching plan. This module provides two ways to realize the data integration, direct import in bulk and manual entry. In addition, ETC-MIS integrate with MDC system to get the state information of machine including fault messages. In order to obtain product structure, BOM, process routes and other technical data, ETC-MIS also integrated with CAD/CAM system, and thus realizing the technical data sharing such as BOM and process route.

3.2.4 Curriculum assignment module

As an instructional management system, computer-aided curriculum assignment is one of the important functions of ETC-MIS. Curriculum assignment of ETC involves many factors, including teachers, students, equipment, classes, courses etc. Curriculum assignment is to realize the practice curriculum arrangement of students and the dispatch of manufacturing resource such as practical training equipment, raw material, semifinished product and instructors in accordance with the teaching program under the premise that needing the teaching resources. The mathematical model and objective function for timetabling problems were established

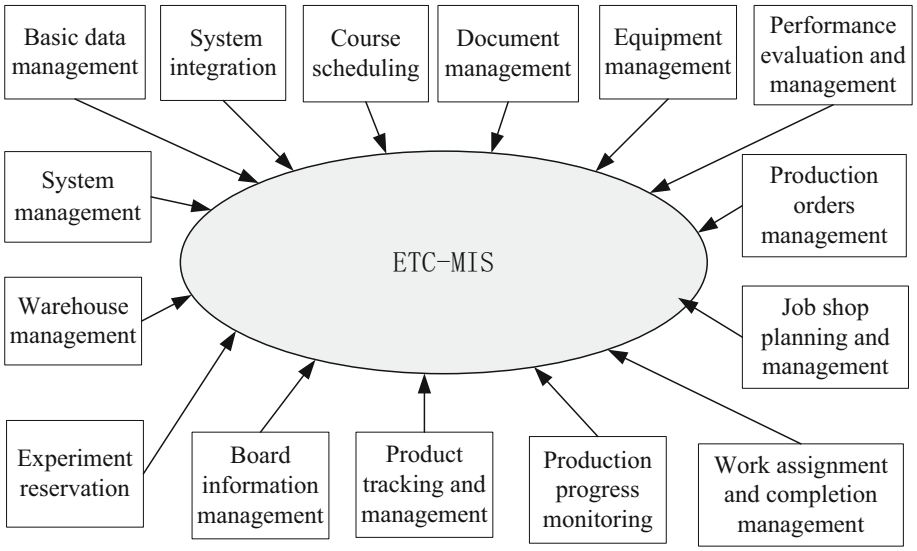

Fig. 3 The system modules of ETC-MIS

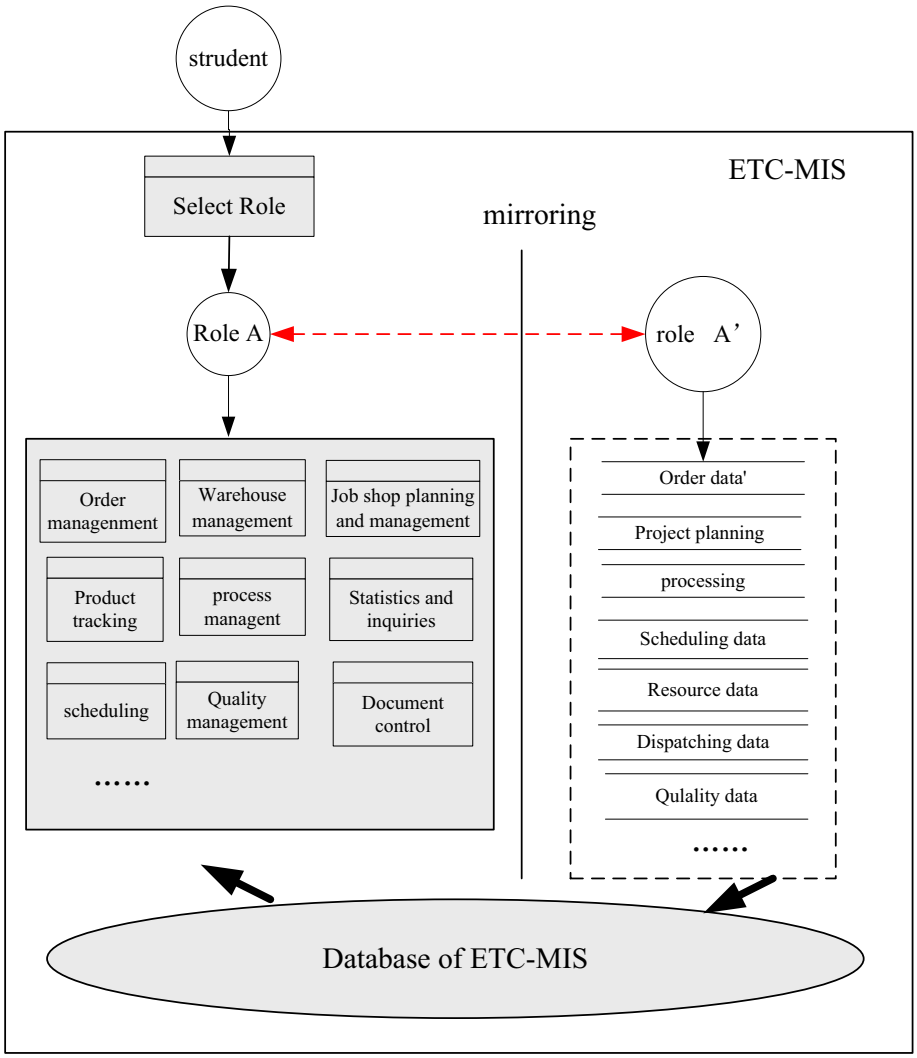

Fig. 4 Role mapping and data mapping

based on the in-depth research on course scheduling for ETC. in this module, a improved particle swarm algorithm (PSO) was used to solve curriculum assignment scheduling problems. Curriculum assignment problem is a complex process. Under the large amount of data and multi-constrained condition, artificial adjustment was adopted based on the results of automatic course scheduling to further optimize the results of course scheduling and thus achieving high efficient and practical effect [18].

Generally, it is unable to find adequate constraints and an optimal solution because course scheduling problem is an NP-complete problem, only find a relatively good approximation. In addition, automatic timetabling is adjusted manually in some universities with different situations. Therefore, a timetable that is enough to satisfy everyone must rely on the combination of automatically and manually.

3.2.5 Document management module

This module may reserve the record and bill related to products, processing regulation or work instructions in addition to manage or distribute document in common production management information system. ETC-MIS document management includes internships outlines, syllabi, practice reports and other materials; besides, it also contains the functions of online reading and downloads for professional datum related to engineering training teaching.

3.2.6 Performance evaluation and management module

This module provides guidance in evaluating the training courses of students, including grades, phase scores and the total score of course. Teachers may evaluate student according to the experimental results, test reports, or the quality of processed products.

Performance management system was established based on the course scheduling system and testing system, it provides a performance management platform for teachers and job training coaches. According to permissions, teachers or training teachers can input, view, modify and delete the students' achievements, and finally calculate the total score of students' engineering training courses based on the input various achievements.

3.2.7 Warehouse management module

This module includes inventory management of raw materials, in and out of storage managements of parts and components, student training products, the tools, measuring tools and work uniforms. Moreover, it provides the function of materials ledger, which not only guarantees the stock of raw materials required to practical teaching, but also ensures that all materials and the use of tools are well documented.

3.2.8 Equipment management module

This module includes basic equipment inventory management, equipment maintenance and repair function, and condition monitoring function of equipment. Besides, this module may manage basic files of devices, such as asset number, device name, model number, date of factory serial number, supplier, price etc, and may also manage configuration files. Flexible query system can flexibly realign the information about device such as general information, configuration, maintenance upgrade file, device records. Moreover, it also flexibly formulates query results, which can be output in form of account card while provide the necessary warnings.

3.2.9 Production orders management module

The order management of daily parts processing includes the functions of order information, order processing progress information, order delivery information. The project was set up based on order form, including general function modules like order receipt, order classification query.

This system is different from normal production order management, in which the order review function is provided in order to ensure the normal development of engineering training and teaching. If delivery requirements in processing tasks are very urgent and processing task conflicts with engineering training and teaching, the production order will not pass the evaluation, which means this order will be turned down. In addition, if the order has already received, then it will be suspended to give way to engineering training and teaching.

3.2.10 Job shop planning and management module

ETC usually only takes order for simple parts processing, in which the processing technology is simple and the production process is not complicated. Therefore, the production plan for the order is very simple. The project was set up based on order and the production was arranged in the form of project. The project plan was worked out according to the delivery date of the order, and then it was divided into workshop operation planning and operations process planning. This module includes the constitution and adjustment of operational planning and the corresponding statistical query functions.

3.2.11 Work assignment and completion management module

First of all, this module assigns teaching tasks to teachers according to teaching curriculum of engineering training and teaching tasks, then teachers will group and dispatch the students and provide dispatch list and material requisition. In addition, the equipments or operators should be

dispatched according to working schedules for external processing orders. In completion management, students should promptly give completion report after completing the classroom training task and input information related to the quality of products. Operators also report after completion, meanswhile record man-hours and material consumption and track the flow of parts.

3.2.12 Production progress monitoring module

This module timely gives feedback and summary of the progress of production orders, especially sounds the alarm to some extrinsic information such as equipment failures in the production process, material shortages, progress lag etc. Managers in ETC should timely grasp the production situation.

3.2.13 Product tracking and management module

This module can carry on read operation in an important position by RFID and bar code on materials and then transfer the information to the system by network, which will timely tracking the location information of products and materials in the workshop of Engineering Training Center, and thus achieving retrospective management of materials, finished and semi-finished products.

Moreover, this module also realizes visual tracking control for the whole manufacturing process, which makes an enterprise realize the tracking control of products during the production and storage as well as transportation process, meanwhile achieves the quality tracking management of products using the collected information.

3.2.14 Board information management module

This module is mainly workshop production management board, including operational plans, plan completion rate, production schedule, equipment operation and maintenance, workshop organization structure, and so on. Moreover, it also includes the practical training information of students such as current practical training content, classes, teachers, and so on. In addition, it also includes exceptional information board, for example, equipment failures, shortage information, teaching exception information, and so on, which are displayed prominently by electronic boar of workshop.

3.2.15 Experiment reservation module

ETC is an open training ground, and students can freely choose the some practical training projects through internet booking. According to the different requirements of different professional, the training content is divided into a series of training units. The time for each cell is set to 1.5–2 h, so that Students can complete the course flexibly in the specified time.

Through the reservation system, teachers can input corresponding course contents to the platform in accordance with the relevant teaching arrangements, and then student may select their own courses within the prescribed teaching schedule, which not only increase the flexibility but also guarantee the controllability of the whole teaching, and thus further raising the utilization rate of resources in Engineering Training Center.

3.3 System structure

Based on the comparative analysis of B/S mode and C/S mode, combined with the actual characteristics of Engineering Training Center, ETC-MIS adopted C/S mode.

Using object-oriented technology, through the modular design method, to ensure the flexibility and scalability of the ETC-MIS. The basic framework of the system and the main application system are based on Web technology. The client uses the Web browser as the user interface. The client uses the Web browser as the user interface, and the workshop operator and related management decision-makers can access the system through the browser. The server uses SQL Server 2000 to store data. The user sends a request to the Web server through the client. After the Web server calls the processing, the result is returned to the client.

Whole system based on SOA architecture, use of WEB technology and object-oriented development language (JAVA), so, ETC-MIS has good openness and scalability.

4 Conclusion

The proposed ETC-MIS was applied to Zaozhuang University Engineering Training Center. This ETC has 20 CNC machine tools, five machining centers, a flexible manufacture line, and set of metalworking practice equipment. The ETC offers 20 training courses for 400 students each year. In addition, every month the ETC has some irregular processing tasks from outside school.

Before ETC-MIS is applied, there are many problems in the ETC of Zaozhuang University. The inventory management is still in the form of manual accounting, which not only increased labor intensity of warehouse manager but also influences the overall management level of ETC. Moreover, warehouse manager cannot know at any time the storage for goods to carry out statistic analysis. it is difficult to master the internal information of training center due to the detached fund flow, material flow and information flow furthermore, which also influences the management level of training center. Course scheduling in most of ETC are still

through artificial way. It requires much time and efforts and in a low quality and efficiency.

Practical application shows the ETC-MIS possesses favorable practicability and versatility under the premise of ensuring the advanced nature of the system. The proposed MIS-ETC has a favorable expansibility and can carry out system reconfiguration, completely satisfying the long-term development need for Engineering Training Center.

On the one hand, ETC-MIS provided management information system covering the whole production process of ETC. it realizes the he product lifecycle management. In addition, the proposed system also has supervision on whole process of entrain teaching, for example, course scheduling, mission distribution, examination, and score management, and so on.

What is more, ETC-MIS the system itself is a teaching system, students can use the system to learn and master the management information system operation. This teaching function is the key factor different from the general commercial software. Use this software, some of the necessary experiments can be set up in ETC. Through this system, the students' understanding for the production mode of the enterprise can be raised, and the ability of operation and practice can also be improved.

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