Application and Exploration of Project Guidance and Machine Learning Techniques in Mechatronics System Design Teaching

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Abstract—In order to improve the deficiencies of the course which focuses on theoretical knowledge lectures but less practical sessions, this paper takes the mechatronics system design course as an example, discusses the implementation method of project practice driven student learning, analyzes the characteristics and advantages of project-based teaching with teaching examples, and proposes a feasible implementation plan. At the same time, based on machine learning technology, a new course teaching effect evaluation system is proposed. Based on the results of software analysis, measures to improve classroom order are proposed for the characteristics of low head-up rate of students in class. The system can overcome the shortcomings of subjective evaluation and also analyze the indicators that could not be measured in the past, which can evaluate the course teaching effect more comprehensively and objectively and efficiently.

Keywords-project guidance; teaching model; machine learning; evaluation system; classroom order

1 INTRODUCTION

Mechatronics system design is an important professional foundation course for mechatronics majors, and is an emerging discipline of cross-fertilization of microelectronics, information technology and mechanical technology [1]. It requires students to master the analysis and design of organic combination of electromechanics, computer digital control program writing, analysis and design of mechatronic transformation of traditional machining equipment [2]. The course in the traditional teaching, mainly to classroom lectures, supplemented by experimental teaching and the actual engineering projects have a certain gap, cannot reflect the cross-disciplinary characteristics of the course, cannot achieve the effect of learning to use, so the reform of the teaching effect for the course is imminent. The current rapid development of artificial intelligence technology, machine learning technology as the representative of the intelligent technology in all walks of life is more and more widely used [3]. Adopting the project- based teaching method based on machine learning technology to reform the mechatronics system course can not only realize the intersection of traditional mechanical and electronic information disciplines, but also improve the practicality of the course and students' learning motivation, while using machine learning technology as a teaching aid can improve the

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efficiency of teaching evaluation and other aspects. Some common machine learning methods include genetic algorithms [4], Monte Carlo methods, linear regression, logistic regression, adaptive augmentation [5] and support vector machines [6- 7]and so on. The introduction of machine learning technology into the research-based teaching and evaluation system of mechatronics system design course, especially the teaching method combined with practical projects, meets the requirements of the development of the times, not only completes the knowledge transfer, but also expands the connection between the discipline and the frontier technology, cultivates students' pioneering and innovative scientific spirit, produces true knowledge from practice, and focuses on ability cultivation and value shaping. At the same time, the use of machine learning technology to establish an intelligent evaluation system of course teaching effect can overcome the shortcomings of subjective evaluation and analyze the indicators that could not be measured in the past, which can evaluate the course teaching effect more comprehensively and objectively and efficiently.

2 DEFICIENCIES IN TEACHING ACTIVITIES AND TEACHING IMPROVEMENT GOALS

The following deficiencies have been identified in the teaching practice of the course:

2.1 Knowledge is more focused on theory and less on practical aspects

The course teaches the main knowledge points such as mechatronic system design methods, selection, and design of mechanical, power and control system components, sensing and control program writing, etc., which contains not only memory-based knowledge, but also mechanics and mathematics. Some students are not sensitive to the formulas and numbers in the books and will feel obscure and difficult to understand. In the course teaching, due to the school conditions and the system design itself has a certain degree of difficulty, students generally reflect that the practical part is small, much theoretical knowledge cannot be verified with practice, it is difficult to master the way and method of system design, the teaching effect is expected to improve.

2.2 The evaluation system of course teaching effectiveness needs to be improved

There are many methods to evaluate the effectiveness of classroom teaching, and the most applied one is to conduct research in the form of questionnaires [8], based on a large amount of data from students' feedback, and to obtain evaluation results by comprehensive scoring according to parameter weights and empirical formulas. This method is somewhat subjective, and some indicators, such as the rate of students' heads up in class, cannot be accurately measured, and thus cannot judge the teachers' classroom management and the effectiveness of course delivery.

As a result, the objectives of the pedagogical reform can be determined as follows:

1)Using machine learning technology and research-based teaching mode to improve the teaching effect of mechatronic system design course, based on engineering practice projects,

to realize the transformation of students from a passive acceptance mode to a teaching and training mode combining "industry, learning and research".

2)Establishing an intelligent evaluation system of course teaching effects by using machine learning technology. To conduct a comprehensive and objective evaluation of the implementation effect of new education and teaching methods and means.

3 PIMPLEMENTATION PROGRAM

In response to the above deficiencies, the following improvement implementation plan was developed:

1) Transform the traditional theory-based teaching to both theory and practice, and guide students to learn in project practice. Mechatronics system has many knowledge points and strong logic, which is especially unfriendly to students with poor foundation in mathematics and physics, and it is difficult for students to remember the knowledge points. In the curriculum arrangement, attention should be paid to interdisciplinary as much as possible, combining machine learning, neural network and other cutting-edge technologies with traditional electromechanical product design. Also based on the cooperation with enterprises in industry-university research to drive teaching. Apply the theoretical knowledge learned in the classroom to the actual research work to solve practical engineering problems. Realize the identity change from traditional learning and accepting type to application and research type [9]. By setting up projects related to engineering problems, decomposing the projects and asking students to complete the design work of each sub-project in the form of grouping, brainstorming design solutions and finally summarizing the overall design tasks, students can cultivate innovative thinking and execution ability in practice, learn from practice and grasp solidly and effectively the course knowledge points.

Project-based teaching exercises students' initiative to learn, their determination to overcome difficulties, and their cooperation in working with their peers. The completion of a project often requires a wide range of literacy, knowledge and abilities, and students get a more comprehensive workout from it. At the same time, students discover other topics related to the project on their own during the project implementation process, promoting innovation. Project-based teaching is not just about completing something or completing a small project, but requires a tight focus on the core concepts, theories, and technologies in the course syllabus, and the implementation of a project in a way that allows students to deeply understand and master the principles and core technologies behind them and can have the actions and initial capabilities to extend and apply them after the project is completed.

Project-based teaching should have a rigorous teaching process design. From the perspective of doing projects in engineering, project-based teaching can be divided into five stages: <1> analyzing students' prior knowledge and industry needs, determining the content of the project, drawing a task breakdown schedule, giving indicators and requirements, and informing the method of assessment. Guiding questions should be carefully designed. Good guiding questions should have room for discussion, generally have no standard solution, cut to the heart of a field or topic, and be challenging. When introducing the project, teachers must make it clear what

problems they want to solve through project implementation, so that students have clearer goals rather than just doing things; <2> Arrange groups, collect information, determine solutions, purchase materials, make engineering prototypes, analyze and test, improve and optimize, and determine results. The process management should also be strengthened to guide students to move forward on their goals, and appropriate grouping can facilitate monitoring and regulate student behavior, assessment, and revision; <3> Presentation of work, which can be products, performances, oral or written reports; <4> Assessment, including expert assessment, process assessment, archival assessment, and peer and self-assessment. Because the content of project-based teaching and learning activities is dynamic, its assessment is more diverse than traditional assessment. The principles of assessment are the work and outcomes of the project should be consistent with the objectives, students should know what is to be assessed, and a rating scale should be prepared. The teacher tells students how doing the project will assess their academic achievement; <5> Revision and reflection, i.e., reflecting on, revising, and optimizing the project to select the best project outcomes.

To complete an engineering project, students submit a final product that may be similar in function, but the technical path of implementation will be different, and the form may vary significantly. Therefore, teachers can evaluate the merits of the project done from the following aspects: <1> the characteristics or innovation of the completed project; <2> the ability to apply the knowledge learned to solve the problem; <3> how much they contributed to the group cooperation; <4> whether the functional requirements of the project product are met and whether the technical parameters indexes are reasonably designed;<5> the feasibility of the implementation of the design scheme.

The following is an example of how to use project practice to drive students to master knowledge. Take the design of an intelligent cart as an example [10], the teacher puts forward design requirements, such as the cart should have a tracking function and voice call function, the vehicle robot claw should be able to grasp 10kg heavy objects, and the vehicle image recognition system should have certain digital recognition function and machine learning function. The students are then divided into small project groups, each group is responsible for the implementation of one function. The group of tracing function should review relevant literature and design a solution to realize the tracing function, such as using infrared sensor, ultrasonic sensor, camera, etc. Analyze and compare the advantages and disadvantages of various solutions and determine the final design solution according to the project design requirements. Then the sensor selection design, to understand what the important technical parameters of the sensor are, which indicators play a key role in the project, determine the type of each component, and give the approximate cost. The robotic claw group should review the use of two-dimensional three-dimensional drawing software, use the knowledge of theoretical mechanics and material mechanics to strength and stiffness check the designed structure, use the knowledge of mechanical principles and mechanical design to determine the transmission mode, carry out three-dimensional modeling of the system, and draw engineering drawings. The image recognition group should first understand and learn the knowledge related to image digital processing, clarify the mathematical algorithm of picture digitization, and then carry out hardware selection and machine learning related to the way of writing the program. Each group should give a clear design plan and selection reason by reviewing the information. The groups are then matched with each other to finally complete the design of the whole cart. Students in the process of completing their respective design tasks, can deepen the memory of the knowledge points in the book, practical experience in the design process of electromechanical

products, in the case of conditions allow, can also be processed, and manufactured finished products, students also have a greater sense of achievement.

Based on the implementation of the curriculum improvement over a period, it is concluded that project-based teaching has the following advantages: <1> students can maintain a stronger curiosity and can achieve the ability to develop lifelong learning; <2> the relationship between teachers and students is more harmonious; <3> students' ability to solve engineering problems is significantly improved; <4> students' ability to acquire and apply knowledge is enhanced; <5> teamwork and communication skills are improved; <6> creativity and innovative thinking are exercised. At the same time, some disadvantages of using the project-led teaching method are also summarized: <1> learning time increases significantly, and many contents need to be completed after school; <2> teachers invest more energy and teaching costs increase; <3> certain processing, design, experimental and other related equipment, and instruments are needed. In general, the use of teaching methods other than declarative teaching generally requires more cost, but the effort is worth it to enhance teaching effectiveness.

2)In response to the objective 2 of the educational reform, it is necessary to adopt the method of artificial intelligence, based on machine learning technology, to establish a new evaluation system for the teaching effectiveness of courses. This system can overcome the shortcomings of subjective evaluation, but also analyze the indicators that could not be measured in the past, and evaluate the course teaching effectiveness more comprehensively and objectively and efficiently. Hardware such as cameras and computers can be used to analyze students' classroom performance based on machine learning algorithms, such as head-up rate and other indicators. The many collected indicators are used as inputs to the intelligent evaluation system, which are transformed into evaluation scores for each student through a neural network model, and from which the teaching effectiveness of the course is judged.

The network structure of the intelligent evaluation model of course teaching effectiveness designed in this paper is RBF neural network. The neuron model of the intelligent evaluation system of teaching effectiveness designed in this paper is shown in Figure 1.

For the teaching quality assessment problem, it can be regarded as a nonlinear mapping of each teaching quality evaluation indicator to the final evaluation result of teaching quality. The number of all evaluation indicators is the number of input nodes of the RBF network, while the number of output indicators (i.e., the evaluation score of each student) is the number of output nodes. In this paper, the BP algorithm based on the Levenberg-Marquardt optimization method is used to obtain the results. After the modeling is completed, the input sample data is input for machine learning, and the neural network model is trained according to the nonlinear mapping relationship, so that the evaluation results can be measured for each input value and compared with the results obtained by the traditional evaluation method.

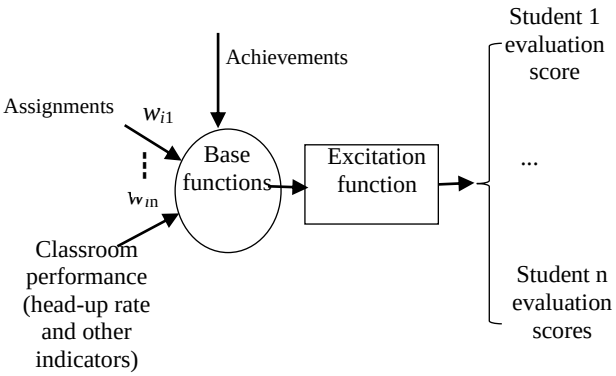

Figure 1 Neuron model of intelligent evaluation system of teaching effectiveness

The intelligent evaluation software of course teaching effect designed in this paper is written by LabVIEW, while MATLAB software is applied to train the neural network, and then its script node is used to embed the neural network completed by MATLAB training into LabVIEW software to jointly write the intelligent evaluation software of course teaching effect, and the software interface is shown in Figure 2.

In this paper, we design the intelligent evaluation software workflow of the teaching effect of the course as follows: the information of students' classroom performance, such as head- up rate, collected from the classroom camera is input into the software in the form of data after image processing and converted into the form of data matrix; the software calls the trained neural network unit and inputs the processed matrix; the output data of the neural network is converted into the score value of each student for each item and displayed. Then the evaluation formula is combined to calculate and display the total score obtained by each student in this class, which is used as a reference basis for evaluating the teaching effectiveness of this class. The intelligent evaluation software based on machine learning algorithm has the features of simple operation, easy debugging, and intuitive output.

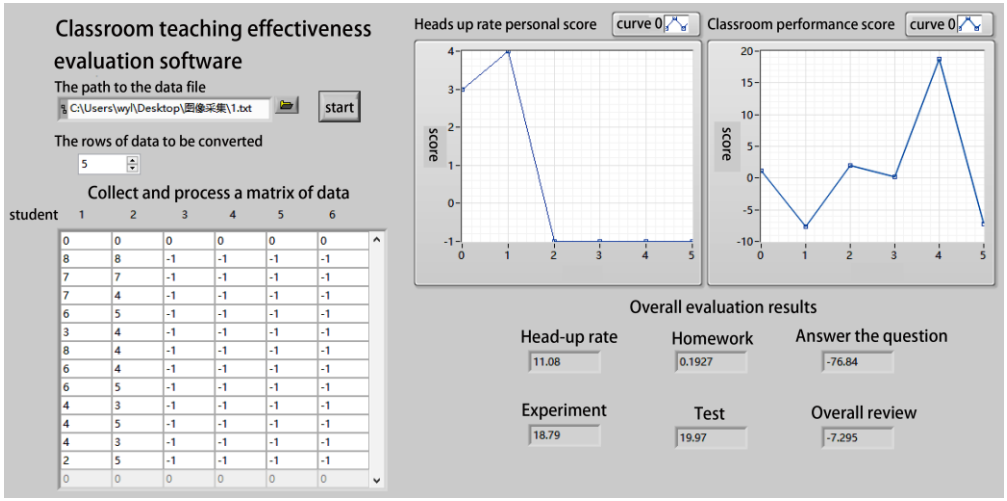

Figure 2. Classroom teaching effectiveness assessment software

3) In terms of classroom order management, the most important way to make students study seriously in class, increase the head-up rate, and reduce the number of people playing with their cell phones with their heads down is to try to improve the teacher's own academic level, so that students will have a kind of oily admiration for the teacher. Then through a certain design of teaching content, through a point of knowledge, side by side, from point to point, strive to achieve a fascinating explanation, so as to reduce the energy spent on maintaining classroom order. If you find that some students are distracted in the classroom, you can see the right moment and ask some questions to such students. If they cannot answer, the teacher should give some hints, inspiration and guidance so that students can answer correctly, deepen their understanding of the knowledge points, and gather students' attention in class. The teacher can give applause and *encouragement to the students who give wonderful answers and can also let the students who have wandered off to return their attention to the classroom teaching content.*

In addition, interspersing case teaching, analysis, and interaction in the teaching process to implement curriculum thinking and political education can also improve students' motivation to listen carefully and help maintain a good learning style in the classroom. For example, taking the Ford recall of 80,000 Impalas with nineteen broken axles as an example, we discuss the causes of the accident and analyze the reasons for the accident by combining the pictures of the broken axle gate of the Impala that occurred in various places.

Extended analysis of the accident brought Ford economic losses, quality losses, and the potential danger to the lives of drivers, followed by the conclusion that materials have an important role in the product, and that only the selection of materials according to standards and specifications can meet the requirements of use. By watching a short video of "I love to invent" stirring friction welding equipment, we introduce the central role of key core technology in the entire product manufacturing and analyze the application of this technology in industry and the role it plays. To encourage the enhancement of national self-esteem, self-confidence, pride and a sense of belonging. Reinforce the importance of innovation awareness.

4 CONCLUSION

The application of project guidance and machine learning technology, while focusing on the combination of local engineering practice projects, can help improve the teaching effect of mechatronic system design courses and realize the transformation of students from a passive learning mode to a learning mode combining "industry, learning and research". The intelligent evaluation system of course teaching effect established by machine learning technology can make a comprehensive and objective evaluation of the effect of new education and teaching methods and means.

REFERENCES

[1] Zhang, J.-M. Mechatronics system design [M].2019,1-4.

[2] Song Jianzun, Zhang Furen. Analysis of the problems of higher education in China[J]. 2012,08:24,40.

[3] Liu Zhiyun, Liu Hongying. The theory and practice of research-based teaching [J]. Teaching Research. 2010,33(04):13-16.

[4] Banzhaf W, Nordin P, Keller R E, et al. Genetic Programming: An Introduction. San Francisco: Morgan Kaufmann[C], 1998, 13:69-80.

[5] Freund Y, Schapire R E. A decision-theoretic generalization of on-line learning and an application to boosting. computing Machinery [J], 1997, 55: 119-139.

[6] Boser B E, Guyon I M, Vapnik V N. A training algorithm for optimal margin classifiers. in: Proceedings of the Fifth Annual Workshop on Computational Learning Theory. asoocistion for Computing Machinery[J], 1992, 22:144-152.

[7] Cortes C, Vapnik V. Support-vector networks. mach Learn [J], 1995, 20: 273-297.

[8] Zeng Guanglu. On the construction of evaluation mechanism in research-based teaching reform[J]. Contemporary Education Theory and Practice. 2012,04(04): 82-84.

[9] Zhang Changhua, Chen Luan, Wang Kesheng, Liu Qunying, Chen Shuheng, WU Yunfeng. Exploration and practice of research-oriented teaching reform of "Electrical Engineering" course[J]. China Electric Power Education, 2020(10): 75-76. DOI:10.19429/j.cnki.cn11-3776/g4.2020.10.032.

[10] Zhang Juan,Xue Jilai. China Metallurgical Education,2018(01):17-19. DOI:10.16312/j.cnki.cn11-3775/g4.2018.01.007.