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Construction of Models for Cultivating Scientific Research Innovation and Practical Abilities of Students Majoring in Intelligent Manufacturing

Xing Li[1,2,a,*], Fujie Wang[3,b]

[1]School of Electrical Engineering & Intelligentization, Dongguan University of Technology, Dongguan, Guangdong, 523808, China
[2]Dongguan Key Lab of Artificial Information Network, Dongguan University of Technology, Dongguan, Guangdong, 523808, China
[3]Elite Engineers College (Innovation Entrepreneurship College), Dongguan University of Technology, Dongguan, Guangdong, 523808, China
[a]lixing8245@163.com, [b]fjwang@dgut.edu.cn
[*]Corresponding author

Abstract: *In the context of Industry 4.0, intelligent manufacturing has become an important way for China's manufacturing industry to achieve transformation and upgrading, and cultivating high-quality and skilled talents that are suitable for it is particularly important. This article adopted a combination of qualitative and quantitative analysis to evaluate the scientific innovation and practical abilities of intelligent manufacturing major college students under the current higher education system in China. Based on big data, a comprehensive education model driven by big data was established to promote the innovation and application abilities of college students in scientific research. Before adopting the new educational strategy, the average score of students remained at 75.94. Before implementation, there were 29 students with scores below 80, and after implementation, there were 22. Through the research in this article, it can not only enhance the comprehensive quality of students, but also cultivate more forward-looking and innovative specialized talents for the intelligent manufacturing industry, which is of great significance for enhancing the international competitiveness of China's manufacturing industry.*

Keywords: *Intelligent Manufacturing Major, Scientific Research and Innovation, Practical Ability, Big Data*

1. Introduction

From around the world, the rapid development of intelligent manufacturing has led to a huge technological revolution in the manufacturing industry. Intelligent manufacturing includes both highly automated production lines and full process data collection, analysis, and application, with the core of improving production efficiency and quality. However, currently Chinese universities still face problems such as outdated teaching models and lack of practical opportunities in cultivating intelligent manufacturing talents. Numerous studies have shown that the above-mentioned issues can affect the improvement of students' overall quality and their ability to face technological challenges in the future. Therefore, this article intends to establish a new talent cultivation model that emphasizes both the depth and breadth of theoretical teaching, as well as practical skill training and innovation ability cultivation. Through the above research, the aim is to cultivate high skilled talents that meet the needs of industrial development in China's intelligent manufacturing industry, and promote sustainable development and technological innovation in China's manufacturing industry.

The purpose of this study is to explore and establish a scientific research model suitable for undergraduate students majoring in intelligent manufacturing. Firstly, this article provides an overview of the current research status and analyzes the problems and reasons that exist in intelligent manufacturing teaching in China. Secondly, based on educational psychology and using data analysis methods, a set of teaching models and strategies aimed at cultivating practical abilities and creativity is studied and designed. At the same time, empirical testing is also conducted on the above-mentioned learning strategies to ensure that the established learning mode can be effectively applied to classroom teaching.

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The main structure of this article is as follows: Firstly, this article reviews the research on intelligent manufacturing and education to determine the theoretical basis and background of this topic. Secondly, a detailed explanation was provided on the methods used in this article, including data collection, processing, and analysis. Finally, the research findings were presented and a detailed analysis was conducted on how different teaching strategies affect students' learning abilities. The research objective of this article is to systematically discuss the talent cultivation mode of intelligent manufacturing professionals from both theoretical and practical perspectives.

2. Related Work

In the intelligent manufacturing industry, the innovation and practical application capabilities of scientific research are important ways to cultivate high-quality skilled talents. These two qualities are directly related to their adaptability and innovation ability in society. Tian You studied the cultivation technology of student innovation ability based on integrating scientific research into practical teaching [1]. Guo Lizhong explored the practical and reform exploration plan for cultivating the innovative ability of medical undergraduate students [2]. Gao Xiaoyi conducted an exploration of the innovative talent training system in applied universities using the "Climbing Class for Talents" at Zhejiang Shuren University as an example [3]. Yu Liang started a research on the path to enhance the scientific research and innovation capabilities of college students from the perspective of new engineering disciplines [4]. Ma Lin conducted practical exploration techniques based on extracurricular scientific research projects and subject competitions to cultivate the innovation ability of college students [5]. The existing research mainly focuses on the development of intelligent manufacturing itself, but lacks integration with teaching systems, especially in cultivating the scientific research and practical abilities of college students.

In the field of intelligent manufacturing, innovation in scientific research not only means mastering new technologies, but also means applying learned knowledge to practice. Wu Suzhen studied the practical and exploratory plan for cultivating scientific research thinking and innovation ability among medical undergraduate students [6]. Zhou Y conducted an exploration of innovative strategies for English teaching and research among college students in the context of artificial intelligence [7]. Huang H examined the impact of the "Innovation and Entrepreneurship Training Program" on the innovation quality of college students from a psychological perspective [8]. Liang K explored the reform of mechanical design basic courses to cultivate engineering literacy and innovation ability [9]. Liu Qian X Y N L conducted a system dynamics study on the innovation capability of platform enterprises from the perspective of multi-agent participation [10]. Although existing teaching models provide some theoretical and technical support, there are still many problems in practical operation, interdisciplinary thinking, and creative practice. This results in students lacking effective strategies and innovative means when dealing with complex industrial problems.

According to recent surveys, although students have a solid theoretical knowledge, their practical and creative thinking abilities are still relatively weak. Most universities have not organically integrated theory with practice, which has resulted in students not being able to adapt well to the needs of industrial development. In addition, some studies also emphasize the application of interdisciplinary abilities in the field of intelligent manufacturing, especially in cultivating students' scientific research and innovation abilities, which is of great significance. This indicates that there is an urgent need to establish a teaching model that can comprehensively improve the theoretical and practical abilities of college students.

3. Methods

3.1 Teaching Strategies for Cultivating Student Abilities

(1) Design of integrated teaching mode of theory and practice

This article adopts a hybrid teaching model that combines online teaching with physical training. Firstly, this article intends to use online teaching platforms to conduct in-depth research on the basic theories in the field of intelligent manufacturing, including machine learning, machine vision, and automatic control [11]. Secondly, practical training sessions such as robot programming and CNC (computer numerical control) machine operation are arranged in the physics laboratory, allowing students to apply the theoretical knowledge they have learned to production, enhancing the

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effectiveness of their learning.

Student skill mastery rating:

$$S_i = \frac{1}{n}\sum_{j=1}^{n}\left(w_j \times p_{ij}\right) \tag{1}$$

Among them, S_i is the comprehensive skill mastery score of the i-th student; p_{ij} is the score of the student on the j-th evaluation indicator; w_j is the weight of the corresponding indicator; n is the total number of evaluation indicators.

(2) Innovative practices driven by interdisciplinary projects

Interdisciplinary research topics are designed, such as a research plan that combines computer science, mechanics, materials, etc., so that students can think about problems from different perspectives and find answers to them. Through cooperation with enterprises, real-life industrial issues can be introduced into projects, enabling students to master the application of intelligent manufacturing technology and cultivate their practical application abilities.

Project innovation rating:

$$C_k = \alpha \times I_k + \beta \times U_k + \gamma \times T_k \tag{2}$$

Among them, C_k represents the total innovation score of the k-th project, while I_k, U_k, and T_k represent the creativity index, practicality index, and technical difficulty index of the project, respectively. Parameters α, β, and γ are weighting factors for these indices, which reflect the importance of different indicators in scoring.

3.2 Feedback and Evaluation

(1) Teaching system with real-time feedback and dynamic adjustment

On this basis, a teaching system based on intelligent feedback is designed, and the learning process of students is monitored in real-time. The system can dynamically adjust the taught content and difficulty based on the actual situation of the students, to ensure that the taught content meets the needs and abilities of the students. At the same time, it can also provide timely feedback to teachers on the learning situation of students, thereby guiding teachers to optimize their teaching strategies.

Team collaboration efficiency:

$$E_m = \frac{\sum_{i=1}^{p} T_{im}}{p} \tag{3}$$

Among them, E_m represents the average cooperation efficiency of the m-th team; T_{im} is the individual contribution time in the team; p is the total number of team members.

(2) Continuous cycle of evaluation and optimization

Students are regularly assessed for both theoretical and practical operations, and are quantitatively and qualitatively evaluated. The teaching effectiveness and satisfaction of the students are analyzed. On this basis, the teaching mode is continuously improved and the teaching methods and content are adjusted to ensure the continuous improvement of teaching quality.

3.3 Support for Teachers and Schools

(1) Improvement of Teacher's Ability

In addition, professional training for teachers is arranged, including advanced production processes and online teaching tools, student data analysis, etc. By improving the professional abilities and teaching methods of teachers, the effectiveness of implementing educational models can be enhanced.

(2) School enterprise cooperation and resource sharing

By collaborating with leading companies in the industry, the aim is to achieve the sharing of advanced equipment, testing materials, and specialized technologies. At the same time, professionals are invited from enterprises to participate in course design and project review, to enhance students' understanding and insights into practical work. Through the research in this article, the aim is to effectively enhance the scientific research and practical application abilities of college students, and

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establish an efficient talent cultivation model that meets the needs of industrial development.

Comprehensive capability development index:

$$D = \lambda \times \overline{S} + \mu \times \overline{C} + \nu \times \overline{E} \quad (4)$$

Among them, D represents the comprehensive ability development index of the student group, and $\overline{S}$, $\overline{C}$, and $\overline{E}$ are the average skill mastery score, average project innovation score, and average team collaboration efficiency of all students, respectively. Parameters λ, μ, and ν are the weights of these components, indicating the importance of different abilities in comprehensive development.

4. Results and Discussion

4.1 Experimental Conditions

In this article, a series of experiments are designed and implemented to verify the effectiveness of the research innovation and practical ability training model for students majoring in intelligent manufacturing.

(1) Experimental environment settings

This article aims to build a big data analysis platform to achieve functions such as data collection, storage, processing, and analysis, providing students with data-driven decision-making training. On this basis, simulation tools such as MATLAB/Simulink and SolidWorks are used to provide a good platform for students to design, simulate, and optimize designs. The innovation experimental base has opened up an independent space for students to apply new materials, developed machine learning algorithms, and researched new production processes.

(2) Evaluation indicators and calculation methods

The efficiency of team collaboration is evaluated by observing the time and communication efficiency of the team in completing the project. Problem solving ability is scored based on the efficiency and results of student problem-solving by simulating problem-solving scenarios in unexpected situations. The application ability assessment comprehensively considers the ability of students to apply theoretical knowledge to practical problem-solving, with a maximum rating of 100 points. This evaluation system comprehensively reflects the comprehensive abilities of students in theoretical learning and practical application, providing a scientific evaluation tool for educational practice.

4.2 Experimental Results

(1) Theoretical knowledge testing

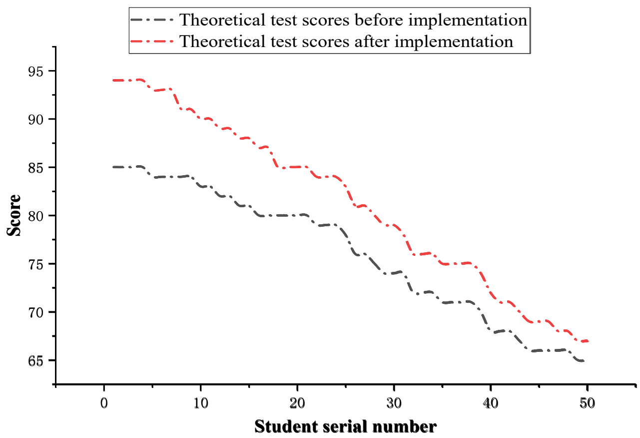

Figure 1: Theoretical knowledge test results

Before adopting the new educational strategy, the average score of students remains at 75.94. After adoption, the data shows an increase in average grades. Under the influence of this strategy, most students have shown an upward trend in their grades. Before implementation, there are 29 students with

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scores below 80, and after implementation, there are 22. The results of the theoretical knowledge test are shown in Figure 1.

(2) Innovation project implementation

This article further conducts innovative project implementation testing, and the member numbers and project names of different groups are shown in Table 1. It includes many intelligent manufacturing projects such as intelligent robot education kits and intelligent environment monitoring devices.

Table 1: Member numbers and project names for different groups

Group	Member number	Entry name
A	001, 002, 003	Smart home control system
B	004, 005, 006	Optimization plan for automated production line
C	007, 008, 009	Intelligent robot education kit
D	010, 011, 012	Intelligent logistics management system
E	013, 014, 015	Intelligent environmental monitoring equipment
F	016, 017, 018	Intelligent medical assistive robots
G	019, 020, 021	Intelligent manufacturing big data analysis platform
Z	048, 049, 050	Customized three-dimensional printing service platform

In this evaluation, the innovation scores of the vast majority of participating groups are between 7.5 and 9.2, indicating a generally high level of innovation. Especially the C and F groups receive high ratings of 9 and 9.2, highlighting their outstanding performance in innovation. By comparison, the scores for groups A and B are 8 and 7 respectively, indicating that there is still room for improvement in innovation for these groups. In terms of practicality ratings, most groups show high scores of 8 to 9.5, indicating the high practical value of these solutions or projects. Especially for group Z, with a score of 9.5 points leading the way, the potential effectiveness of its solution in practical application is extremely significant. In addition, the practicality scores of groups E and F also demonstrate the effectiveness and feasibility of their schemes. Overall analysis shows that most groups have outstanding performance in terms of project innovation and practicality, with groups C and F receiving higher evaluations in both aspects, while group Z, although slightly lower in innovation ratings, has the highest practical evaluation. The innovation and practicality scores for different groups are shown in Figure 2.

(3) Team collaboration ability test

The working hours of group A and group F are 8 and 6 hours respectively, while group B requires 10 hours and group E requires 11 hours. Group F scores 9.2 in communication efficiency, fully reflecting their efficiency and fluency in communication. In addition, groups C and A also have strong communication skills, with scores of 9 and 8.5. The communication efficiency score of group B students is very low, only 7.5 points, indicating that they have certain obstacles in communication. If the cooperation efficiency of group B is low, it indicates that there are some areas that need improvement. This study finds that team management and collaboration skills are crucial for project performance during project execution, as well as the important role of communication in project execution. The results of the team collaboration ability test are shown in Figure 3.

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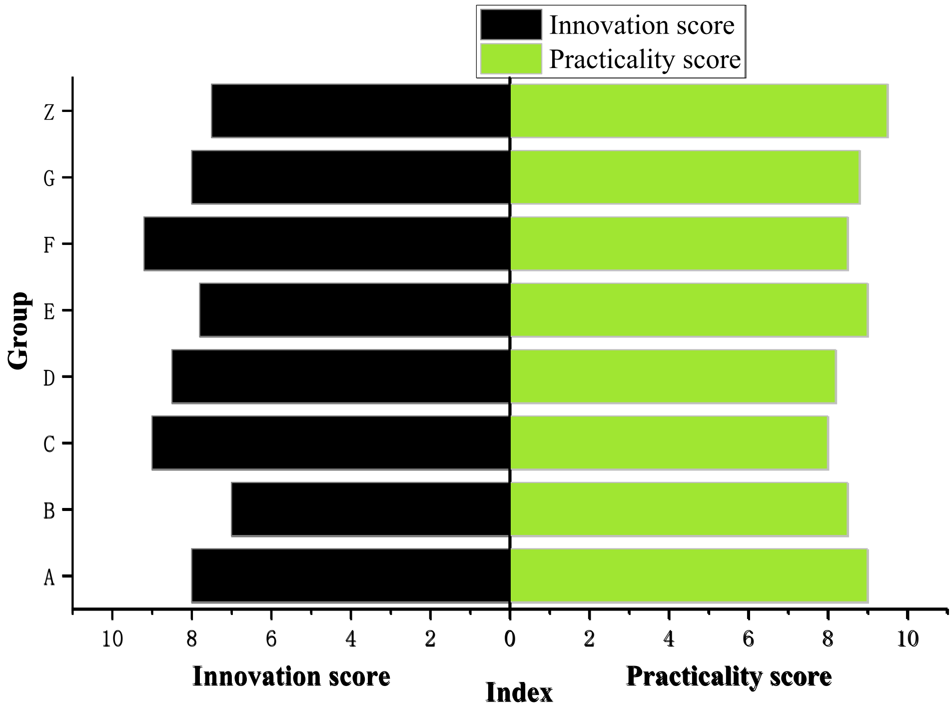

Figure 2: Innovation and practicality ratings for different groups

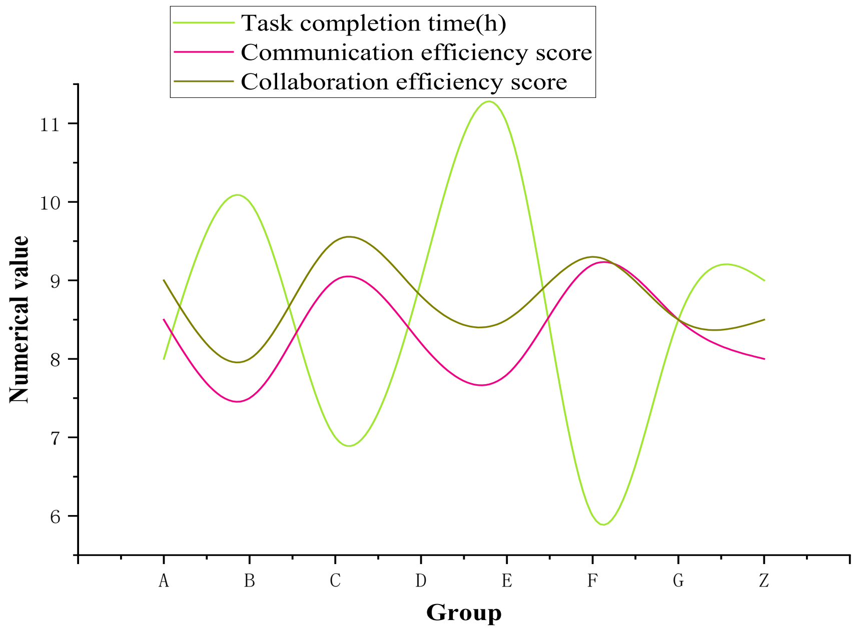

Figure 3: Team collaboration ability test results

(4) Emergency problem-solving testing

In recent fault simulation evaluations, students 001 and 004 quickly identify problems in machine and sensor fault categories, demonstrating high sensitivity and responsiveness to hardware failures. However, student 002 shows slower performance in the process of discovering software errors, suggesting the need to strengthen their abilities in software fault identification and handling. Student 003's quick response to material supply issues reflects their proficiency in production processes or material management. Students 002 and 004 score high on the correctness of the problem-solving steps, demonstrating their organization and accuracy in problem-solving. However, student 003 scores lower on this item, indicating their shortcomings in ensuring the correctness of the operational steps. The results of the emergency problem-solving test are shown in Table 2.

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Table 2: Emergency problem solving test results

Student number	Fault simulation type	Fault discovery time (seconds)	Fault resolution time (minutes)	Correctness score for solving steps (out of 10)
001	Machine malfunction	30	10	8
002	Software error	45	15	9
003	Material supply issues	20	8	7
004	Sensor malfunction	35	12	10
...	...	...	...	...
050	Communication interruption	40	13	8.5

(5) Comprehensive application testing of theory and practice

In this student ability assessment, student 001 demonstrates a high level of theoretical knowledge and practical operation, with high scores in both theory and practice, demonstrating his solid foundation and good execution ability. Although the comprehensive application ability is also relatively high, there is still room for further improvement. Student 002's rating indicates that they are able to apply theoretical knowledge well in practice, with theoretical scores slightly higher than practical ones, reflecting a good combination of theory and practical application. Student 003's operational ability is significantly better than their theoretical level, indicating strong performance in practical skills, but the theoretical foundation still needs to be strengthened. Student 004 scores high in both theoretical and practical tests, and his comprehensive application ability is even more perfect, reflecting his comprehensive ability. These results reflect the different performances of students in theory and practice, and provide valuable insights for further education. The comprehensive application test results of theory and practice are shown in Table 3.

Table 3: Comprehensive application test results of theory and practice

Student number	Theoretical question score	Practical operation score (out of 100)	Comprehensive application ability score (out of 20)
001	85	90	18
002	92	85	19
003	78	88	17
004	88	92	20
...	...	...	...
050	80	80	16

5. Conclusion

This article focused on students majoring in intelligent manufacturing and conducted research from both theoretical and empirical perspectives. A comprehensive teaching model was constructed by combining theoretical lectures, practical operations, interdisciplinary thematic research, and instant feedback mechanisms. Practice has shown that after adopting the teaching mode designed in this article, students have significantly improved their mastery of theoretical knowledge, practical operational skills,

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team collaboration efficiency, and problem-solving. Especially in practical activities, students demonstrate strong creative thinking and the ability to solve practical problems. Although the research results of this article preliminarily prove the effectiveness of the model, there are also certain limitations. Firstly, the sample size participating in this survey is relatively small and limited to a few college students. Therefore, the universality of this model and its impact on different teaching contexts still need further testing. Secondly, due to the short research period, it is not possible to comprehensively evaluate its long-term impact on student learning ability. In the future, further expansion and deepening are needed: first, the sample and experimental scale are expanded to make it applicable to different regions and types of universities, in order to test and improve the universality of educational models. Secondly, to track the long-term development of students, a more comprehensive evaluation of the sustained effects of the model should be conducted. On this basis, this article also delves into the development trends of intelligent manufacturing technology, and combines it with teaching modes to continuously update and optimize teaching content, making teaching modes forward-looking and practical. Ultimately, a group of intelligent manufacturing professionals with strong independent intellectual property rights can be formed.

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