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An Exploration of Teaching Method Innovation in Embedded System and Design Course Based on Chatgpt Empowerment

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Abstract

With the booming development of generative artificial intelligence in recent years, many excellent big-prophecy generative models such as ChatGpt have emerged, and these models have gradually entered the field of intelligent education with their powerful input information comprehension and response text generation capabilities. In this paper, we will focus on the teaching of embedded system and design course for IoT professional college students, deeply analyse the characteristics of the college student source, and put forward a classroom teaching model suitable for college students, based on the BOPPPS teaching exploration to introduce the ChatGPT empowerment, and by incorporating the ChatGPT into the six segments of course introduction, goal formulation, pre-testing, participatory learning, post-testing and summarising, to provide intelligent teaching support to help students make up for knowledge deficits and stimulate learning interest, while optimising the efficiency of teachers' lectures, this paper aims to provide a reference for the innovation of post-secondary students' teaching mode and promote the further improvement of the teaching quality of Internet of Things engineering.

Keywords

Specialist-to-bachelor degree student; ChatGpt; BOPPPS Teaching Model; Intelligent Education.

1. Introduction

With the booming development of the Internet of Things (IoT) industry, IoT devices in several intelligent fields such as consumer electronics, medical electronics, intelligent control, intelligent agriculture, smart home, etc. cannot be separated from the support of embedded systems, so Embedded System and Design is one of the important course components for IoT engineering majors. At the same time, as a bridge connecting hardware and software, the development of embedded systems also plays a key role in the functional realisation of IoT devices. The course content takes Exynos4412 core processor as the core, and explains the processor architecture in depth, covering key modules such as ARM instructions and assembly instructions, GPIO, clock management unit, interrupt system, DMA control, PWM timer, UART interface, I2C interface, ADC converter, etc., and guides the students to learn practical skills in the development of embedded systems, such as porting U -BOOT, etc. Through the course, students can systematically master the hardware and software foundation of embedded system, and at the same time cultivate students' hardware and software co-development ability.

Obviously, this is an extremely comprehensive course, a knowledge domain involving multiple technical fields, and learning it requires a solid body of prior knowledge [1]. Students must have the basic knowledge of multiple courses in advance such as Wireless Sensor Networks, Principles of Computer Composition, Principles of Operating Systems, Data Structures and Algorithms, Fundamentals of Microcontroller Technology, Circuits and Electronics, C Programming, and Professional English. However, in the context of specialist to undergraduate

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education, the teaching of this course faces greater difficulties due to the following two main reasons:

(1) Many students upgrading from speciality to bachelor's degree have a weak foundation in the direction of Internet of Things (IoT). The professional backgrounds of students upgrading from speciality to undergraduate are complex, and many of them have not received systematic IoT engineering-related courses at the speciality level. For example, some students have never learnt C language or microcontroller technology at the specialist stage, which are the important pre-requisite knowledge for Embedded System and Design. According to the interviews with some students, it was learnt that some students' specialties were not related to computer science, which directly led to a significant shortcoming in their undergraduate studies. In addition, undergraduate study is usually only two years long, and by default students have already mastered the basics, so the learning pressure on students from speciality to undergraduate study is further increased.

(2) The total number of hours in the course on embedded systems and design is insufficient: the total number of hours in the course is 64, of which 40 hours are devoted to theoretical lectures and 24 hours to in-class practical training, with 12 chapters on bare-metal development and 2 chapters on Linux-based operating systems. As some of the students lacked computer-related background knowledge, the classroom content was difficult for them to understand. At the same time, if the instructor needs to take care of their learning progress, he needs to add a lot of extra knowledge, which undoubtedly increases the difficulty of teaching.

With the rapid development of artificial intelligence technology, generative pre-training models (e.g., ChatGPT) have demonstrated powerful language generation and information processing capabilities [2]. After some training, such models can answer the basic knowledge questions of many professional courses, and their potential in the field of education is gradually emerging. Currently, more and more educators are exploring the application of ChatGPT in classroom teaching to optimise the teaching effect and enhance the learning experience.

For example, Du Qiuyu explores the integration of ChatGPT in education teaching in ‘The Integration of ChatGPT and Education Teaching: Innovative Methods and Practices’. The paper points out that with the personalised guidance and feedback provided by ChatGPT, students can be helped to better understand and master their knowledge, and improve their learning effectiveness and interest [3].

Yin Yuelin and Gao Mingjing proposed in ‘Research on the Application of Generative Artificial Intelligence in the Teaching Reform of Logistics Management’ that ChatGPT empowers the whole teaching process of logistics management professional courses, including teachers‘ lectures, students’ learning, assessment and evaluation, and the management system, so as to enhance the educational capacity and promote the development of high quality in education [4].

In addition, Chen Xuanxuan, Guo Yupei, et al. mentioned in ‘Focus on the Future: Exploration of PBL Teaching Models Empowered by ChatGPT’ that teachers can use ChatGPT as a tool to assist PBL (Problem-Based Learning) classrooms, to build a PBL-ChatGPT learning scaffold for students, and as a teaching diagnostic tool after the class, to form a complete closed loop of PBL teaching [5].

Wu Suhan and Luo Min pointed out in ‘Research on Teaching Practice Paths Based on Generative AI - Taking Business Data Analytics as an Example’ that generative AI can be used to simulate more business environments to enhance the ‘Business Data Analytics’ course. Business data analysis applications’ course interactivity and practicality, to further improve the teaching effect [6]. In addition, in the BOPPPS teaching mode (Introduction, Objectives, Pre-test, Participatory Learning, Post-test, Summarisation) that has emerged in recent years, ChatGPT has also demonstrated significant advantages in empowering these new teaching modes, which

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can assist in the generation of teaching content, the design of learning paths, optimising classroom interactions and efficiently summarising knowledge. These functions not only help students make up for shortcomings in their knowledge, but also stimulate their interest in learning, which significantly improves the effectiveness of course learning.

In this paper, we take the students of IoT majors as the research object, and discuss the application and practice of BOPPPS teaching mode based on ChatGPT empowerment in Embedded System and Design course. By analysing the learning characteristics of students from speciality to undergraduate degree and combining the functions and advantages of ChatGPT, innovative teaching strategies are proposed to solve the following problems:

(1) With the personalised learning function of ChatGPT, customise the learning path for students with a weak foundation, make up for their knowledge blind zones, and help them quickly keep up with the course progress.

(2) Integrate ChatGPT in all aspects of the BOPPPS teaching model to explore an innovative teaching model to enhance students' classroom learning.

The purpose of this paper is to provide new ideas for the course teaching of Embedded System and Design, and at the same time to promote the development of professionalism and comprehensive ability of students from speciality to undergraduate.

2. Feasibility Analysis

2.1. Introduction to ChatGpt

Generative Artificial Intelligence (GAI) is an AI technology that learns and creates original content from large-scale data through complex algorithms and models, and is capable of generating multiple forms of content, including text, images, sound, video, and code, etc. [7] ChatGPT is an outstanding representative in the field of Generative Artificial Intelligence. field, developed by OpenAI, USA, and built based on the GPT (Generative Pre-trained Transformer) model. As a large-scale language model, ChatGPT has 175 billion parameters and is one of the most advanced natural language processing technologies today [8]. It is not only capable of conducting natural dialogue and answering various questions, but also has a variety of capabilities such as text generation, summarization, translation, etc., which demonstrates the powerful functions and broad application prospects of generative AI technology [9].

With the continuous upgrading of the technology, ChatGPT's capabilities continue to improve in various aspects, including more accurate understanding of context, generation of richer answers, and more efficient processing of natural language tasks. In addition, the application scope of ChatGPT is rapidly expanding, showing great potential in the fields of education, healthcare, and entertainment, providing people with convenient and intelligent services. For example, in the field of education, ChatGPT can help students acquire knowledge more efficiently through personalised learning tutoring, in the field of healthcare it provides intelligent auxiliary support for patients and doctors, and in the field of entertainment it creates interactive user experiences.

With the further maturation of generative AI technology, ChatGPT is expected to bring about far-reaching changes in various industries, especially in the field of education, promoting the development of personalised teaching models and bringing people a more efficient and intelligent learning experience.

2.2. Introduction to the BOPPPS Instructional Model

The BOPPPS model is a structured, student-centred instructional design framework [ ], consisting of six key components:

(1) Beginning: Introducing the course content by stimulating students‘ interest, attracting students’ attention and laying the foundation for subsequent learning. 2;

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(2) Objective: Define the knowledge and skills that students need to master, so that the learning objectives are clear and specific. 3;

(3) Pre-assessment: to test students‘ prior knowledge and ability, and to assess students’ starting point for learning. 4;

(4) Participatory learning: guiding students to actively participate through interactive tasks to promote deep learning. 5;

(5) Post-assessment: testing the achievement of learning objectives and assessing students‘ mastery of knowledge. 6. Summary: testing the achievement of learning objectives and assessing students’ mastery of knowledge;

(6) Summary: helps students to sort out the core knowledge of the course and promotes knowledge integration and reflection.

The BOPPPS teaching model focuses on clear goal setting, classroom interaction, and closed loop feedback, and is an effective teaching method widely used in modern educational practice.

The advantage of this model is that the classroom design is clearly structured, and through phased teaching, the course content can be reasonably arranged, and the teacher's teaching and students' learning process is more organised. Clear teaching objectives can guide students' attention and help them focus on the core content of the class, thus enhancing learning efficiency. Pre-tests and post-tests assess students‘ knowledge in a timely manner, helping teachers to identify students’ learning problems and make timely adjustments to their teaching strategies. The increased classroom interaction also promotes student participation and makes the learning process more lively.

However, the BOPPPS model also has certain shortcomings. For example, it has a relatively low degree of personalisation. The model assumes that students have a certain level of basic knowledge in order to follow the rhythm of the teacher, but if the students' foundation is relatively weak, the classroom may become one-way and it is difficult for students to actively participate, leading to poor classroom results. In addition, the design of each session requires sufficient pre-preparation, and teachers need to spend a lot of time planning diverse teaching activities, assessment tools and methods, which increases the teaching load. Finally, despite the feedback sessions, students may not be able to receive targeted individual advice, which limits their personalised enhancement in learning.

Overall, the BOPPPS model is effective in enhancing the quality of teaching and learning in the classroom through its clear structure and interactive design, but its implementation is still affected by students' basic and individual needs.

2.3. Analysis of students' learning situation

In this study, 35 students in the class of 2023, specialising in Internet of Things Engineering to undergraduate level, were selected to conduct a questionnaire on their undergraduate institutions and professional backgrounds, and the results of the survey are shown in Figure 1. According to the analysis of the survey data, the students in the class came from 21 different specialist colleges and covered 21 different specialist majors. From the data, it can be seen that there are 18 students in computer-related specialist majors (e.g., software technology, cloud computing technology and application, big data technology and application, computer network, etc.), accounting for 51.4%; there are only 5 students in IoT-directly related majors (e.g., IoT application technology, embedded technology and application, etc.), accounting for 14.3%; and there are only 5 students in IoT-unrelated specialist majors (e.g. Mobile Business, Construction Engineering Technology, Food Nutrition and Testing, Hotel Management, etc.) accounted for 85.7% of the students.

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Table 1. Three Scheme comparing

Num	Name	School number	Previous colleges	Major
1	Lu**	2023*******	Jiangmen Institute of Vocational Technology	New Energy Vehicle Operation and Maintenance
2	Li**	2023*******	Guangdong Institute of Science and Technology	Software Technology
3	Xu**	2023*******	Guangdong Institute of Science and Technology	Cloud Computing Technology and Application
4	Liu**	2023*******	Qingyuan Vocational and Technical College	Computer Network Technology
5	Liao**	2023*******	Qingyuan Vocational and Technical College	Big Data Technology and Application
6	Chen**	2023*******	Guangzhou Huashang Vocational College	Computer Network
7	Lu**	2023*******	Huizhou City Vocational College	Hotel Management
8	Lin**	2023*******	Guangdong Traffic Vocational and Technical College	City Railway
9	Huang*	2023*******	Guangzhou City Vocational College	Software Technology
10	Zhou**	2023*******	Guangdong Water Conservancy and Electric Power Vocational and Technical College	Cloud Computing Technology and Application
11	Mo**	2023*******	Guangdong Water Conservancy and Electric Power Vocational and Technical College	Underground and Tunnel Engineering

This data intuitively reflects the complex and diversified student source structure of the current post-expansion speciality-to-bachelor's degree, with a significant proportion of non-IoT majors, which leads to the following three major problems in the teaching of Embedded System and Design course:

(1) Great differences in the structure of the student population and different professional foundations

Embedded System and Design is a course with high requirements for comprehensive ability and hands-on ability, covering theoretical learning and 24 hours of practical courses. Classroom teaching requires students to operate the embedded experiment box, write code and debugging, therefore, students are required to master a series of pre-requisite courses, such as C language, data structure, microcontroller, principles of computer composition and so on. Usually this course is set in the second semester of the third year of undergraduate study or the first semester of the second year of upgrading to bachelor's degree. However, some students from non-computer-related disciplines who have been promoted to undergraduate programmes have indicated that they have not studied basic courses such as C language and principles of computer composition in their undergraduate programmes, and the curriculum after they have been promoted to undergraduate programmes has not supplemented such knowledge. Therefore, they faced greater difficulties in learning Embedded System and Design. Especially when explaining hardware knowledge such as registers, GPIO, UART, DMP, etc., students often find it difficult to concentrate on learning; when carrying out in-class practical training in C language or assembly language development, many students are intimidated by the course, and some of them are close to zero foundation, and over time, they gradually lose their interest in learning.

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Table 2. Three Scheme comparing (Continued)

Num	Name	School number	Previous colleges	Major
12	Liang**	2023*******	Dongguan Vocational and Technical College	Internet of Things Application Technology
13	Yi**	2023*******	Guangdong Science and Trade Vocational College	Embedded Technology and Application
14	Liu**	2023*******	Guangdong Post and Telecommunication Vocational and Technical College	Software Technology
15	Zhong**	2023*******	Heyuan Vocational and Technical College	Mobile Communication Technology
16	Huang**	2023*******	Huizhou Engineering Vocational College	Internet of Things Applications
17	Ye**	2023*******	Guangdong Post and Telecommunication Vocational and Technical College	Cloud Computing Technology and Application
18	Zhou**	2023*******	Guangdong Environmental Protection Engineering Vocational College	Food Nutrition and Testing
19	Li**	2023*******	Guangdong Science and Technology Vocational College	Cloud Computing
20	Lin**	2023*******	Guangdong Science and Technology Vocational College	Industrial Robotics
21	Huang**	2023*******	Guangdong Xin'an Vocational and Technical College	Internet of Things Application Technology
22	Zhu**	2023*******	Guangdong University of Commerce and Industry	Software Technology
23	Zhang**	2023*******	Guangdong Water Conservancy and Electric Power Vocational and Technical College	Harbour Navigation and River Engineering
24	Zhang**	2023*******	Huizhou City Vocational College	Internet of Things
25	Jiang**	2023*******	Guangdong Science and Technology Vocational College	Mobile Business
26	Li**	2023*******	Jieyang Institute of Vocational Technology	Mechatronics
27	Shi**	2023*******	Guangdong Vocational College of Foreign Language and Arts	Modern Education Technology
28	Li**	2023*******	Guangdong Institute of Science and Technology	Software Technology
29	Liang**	2023*******	Guangdong Institute of Science and Technology Vocational College	Architectural Engineering Technology
30	Lv**	2023*******	Guangzhou Institute of Commerce and Industry	Computer Networking

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(2) The existing classroom teaching mode does not match with the students who have been promoted from speciality to undergraduate.

The Embedded System and Design course is offered in both speciality to undergraduate and undergraduate majors, but there is usually no difference in the teachers, teaching materials and teaching mode of the course. In terms of textbook selection, students from speciality to undergraduate degree often follow the undergraduate textbooks, while publishers usually have not introduced specific textbooks for students from speciality to undergraduate degree, so these textbooks have certain knowledge barriers for many non-speciality students from speciality to undergraduate degree. In terms of classroom teaching, the traditional teaching mode usually focuses on knowledge points, teaching embedded chip control methods, and writing and verifying codes through experiment boxes. However, for students who have not systematically learned C programming and data structure from speciality to undergraduate, there are greater difficulties in writing programs independently. Each student's basic situation is different, so the traditional undergraduate teaching mode may not be suitable for students from speciality to undergraduate. It is necessary to explore a teaching mode that better meets the learning situation of students from speciality to undergraduate, in order to improve their learning effect.

(3) Specialist to undergraduate students are under great pressure to study the course.

Specialist to undergraduate students usually face higher academic requirements and employment pressure. Students with a weak foundation are often confused when facing the course Embedded System and Design, not clear about what knowledge points they need to make up, and they do not know how to make a study plan to catch up with the course progress. As a result, they may suffer from greater psychological pressure in the learning process. Such pressure not only affects their motivation to study, but may also have an adverse effect on their mental health.

The above analyses show that the backgrounds of students from speciality to undergraduate programmes are more diverse, and the existing teaching mode may not be able to meet their learning needs. Therefore, to address these problems, more flexible teaching strategies are needed to help students overcome their learning difficulties and enhance their learning outcomes.

3. An Exploration of the Innovation of BOPPPS Teaching Model Based on ChatGPT Enabling

The BOPPPS teaching model is an efficient classroom teaching design method based on constructivist theory, which emphasises student-centredness, and builds a complete teaching loop through a systematic six-step teaching process, so as to enhance students' participation and learning effects.BOPPPS consists of six key links: Bridge-in, Objective, Pre-assessment, Participatory Learning, Post-assessment and Summary. Pre-assessment, Participatory Learning, Post-assessment and Summary. This paper explores how to empower AI technologies (e.g., ChatGPT) into various aspects of BOPPPS teaching to help solve the learning difficulties of speciality to undergraduate students in Embedded Systems and Design course, and at the same time, provide teachers with diversified teaching resources and real-time aids to enhance the classroom teaching effect.

3.1. Bridge-in

The classroom adopts the group teaching mode, and the pre-study tasks are released through Super Star Learning Pass before the class. Each group uses GPT to design interesting dialogue scenarios based on the UART communication knowledge points to be learned. For example, simulate the UART communication process between two devices, set the dialogue content, such

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as 'how to negotiate the baud rate', 'why the data verification fails', etc., and demonstrate the basic process through role-playing. This kind of introduction can stimulate students' interest, and at the same time achieve the effect of flipped classroom, encouraging students to carry out preliminary thinking and discussion. Examples of specific dialogue scenarios are shown in Table 3.

Table 3. UART communication simulation table

Character	Dialogue content
Device A: (Xiao Ming)	'Hey, Device B! We need to start communicating. Are you ready? My default baud rate is 9600, how about you?'
Device B: (Xiao Hong)	'Wait, Device A! The default baud rate on my side is 115200. it looks like we're not on the same channel yet, and the data will be wrong. We'll have to negotiate the baud rate first!'
Device A: (Xiao Ming)	'Okay, then it's safer if we standardise to 9600. Please adjust the configuration.'
Device B: (Xiao Hong)	'Okay, the baud rate has been changed to 9600! Then shouldn't we set the data frame next? The default on my side is 8 data bits, 1 stop bit and no parity bit.'
Device A: (Xiao Ming)	'No problem, my configuration is the same, so it's compatible. Let's start sending test data!'
Device B: (Xiao Hong)	'Got your data! Wait, why does some of the data look wrong? For example, the character 'A' isn't showing up correctly, so maybe there's a problem with the data checksum.'
Device A: (Xiao Ming)	'Oh, there might be interference in the transmission. Shall we add a parity bit to ensure data integrity?'
Device B: (Xiao Hong)	'Okay, I'll adjust it to Odd Parity now. Try sending the test data again!'
Device A: (Xiao Ming)	'Data sent, is the display working?'
Device B: (Xiao Hong)	'Perfect! No problems with the data this time. It looks like our configurations are finally in agreement, and communication can proceed normally!'
Device A: (Xiao Ming)	'Great! I'm going to send a string next, so get ready to receive it.'

3.2. Objective

Clear learning objectives help students to focus on key knowledge points, avoid ineffective learning, and provide them with a basis for making study plans. Particularly for students with weak foundations, clear objectives enhance motivation and make the class more focused and organised. Teachers clarify the learning objectives to students at this stage, such as:

- Master the basic concepts and working principles of UART communication
- Understand the composition of the UART data frame and the key parameters of the baud rate setting
- Completing basic data transmission experiments based on UART

In addition, students can use the GPT to generate personalised learning guides to help them identify what they need to add and provide feedback on what they don't understand, so that teachers can adjust their teaching strategies accordingly.

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3.3. Pre-assessment

Pre-assessment helps teachers understand students' knowledge base and learning needs, so that they can adjust the content and pace of teaching. Taking UART communication as an example, teachers can use GPT to quickly generate relevant quiz questions, such as:

- Definition of baud rate in UART communication?
- Draw the structure of UART data frame and mark the function
- Briefly describe the difference between UART and SPI communication

Teachers can design a 5-10-minute pre-test to help understand the basic mastery of students and adjust the pace of teaching in a targeted manner.

Step 4 Participatory Learning

Participatory Learning involves students in the classroom through interaction and practice to enhance the initiative and depth of learning. The teacher first explains the knowledge points, and then students use GPT to generate the basic code for the experiment, reducing input time and helping students to check and improve the generated code. This process improves students‘ understanding of the code, avoids the traditional single code input method, and stimulates students’ creative thinking.

3.4. Post-assessment

Post-assessment helps teachers to assess students' mastery of classroom knowledge and identify blind spots. Teachers can use GPT to generate questions related to the classroom content. A 5-10 minute post-assessment can help students consolidate their knowledge and correct misunderstandings in a timely manner. The post-test provides data for teachers to optimise the teaching design and ensure that the learning objectives are achieved.

3.5. Summary

The summary helps students to organise their classroom knowledge and form a clear cognitive framework. Students identify the key points in the classroom and input them into the GPT to generate a summary. After reporting in groups, the teacher will make comments to further deepen students' understanding and lay a solid foundation for subsequent learning.

By integrating ChatGPT into the BOPPPS teaching mode, it can not only enhance students' learning participation and effectiveness, but also provide teachers with instant feedback and assistance, helping to optimise and innovate classroom teaching.

4. Summary

The integration of ChatGPT and BOPPPS teaching model brings more possibilities for IoT engineering specialist to undergraduate education. In the course of Embedded System and Design, ChatGPT can be involved in many aspects of teaching, helping students to make up for the shortcomings of knowledge, stimulating learning interest and improving learning effect. By creating interesting dialogue scenarios in the ‘Introduction’ section, assisting in the formulation of personalized learning plans in the ‘Learning Objectives’ stage, and helping teachers to assess students' foundation in the “Pre-test” section, ChatGPT is able to help students to learn more about embedded systems and design and to improve their learning results. The ‘Participatory Learning’ stage supports the improvement of practical skills, the ‘Post-test’ examines the learning outcomes, and the ‘Summary’ stage guides the compilation of knowledge. ChatGPT significantly optimises the teaching and learning process and improves classroom interaction.

However, while this model brings opportunities, it also faces some challenges. Firstly, the accuracy and reliability of the content generated by ChatGPT still needs to be improved, and the students‘ reliance on the tool will have a certain impact on some students’ ability to learn independently, and secondly, the integration of the new tool puts forward higher requirements

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on teachers' mastery of the technology in the whole teaching process, in particular. All these issues to be solved and improved need to be focused on in our future research, including optimising the quality of generated content, balancing the relationship between students' reliance on tools and their independent learning, as well as providing teachers with more easy-to-use technical support.

With the continuous development of AI technology, this integration model is expected to further meet students' personalised learning needs and promote the reform and innovation of the teaching mode of IoT engineering. Through continuous optimisation and practice, this mode will inject new vitality into the education of specialists to undergraduate education, improve the quality of education, help students' all-round development, and provide strong support for the professional teaching reform.

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