Research on the Ways to Cultivate Composite Talents in Transportation Engineering With the Assistance of Micro Majors

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Abstract. The development of smart transportation requires professionals in transportation engineering to possess interdisciplinary knowledge and abilities. In this paper, a new talents cultivating method guided by projects is explored. Taking the ‘Portable Traveled Surface Roughness Test System’ project as example, the inter-generational transmission of knowledge through project circulation, deep development of the project, students micro-professional learning driven by the in-depth development of projects, and the cultivation of composite talents to feed back the research and innovation of mentors are introduced. The full cycle of project iterations provides a new reference path for the cultivation of versatile talents in transportation engineering.

Keywords: composite talents; talents cultivation; project iteration; micro major

1. INTRODUCTION

The cultivation of new engineering talents[1] and the all-round development of intelligent transportation have prompted traffic engineering talents to have knowledge of intelligent detection, signal analysis, big data processing, vehicle-road collaborative design, and even information security on the basis of knowledge of traffic infrastructure, planning, and management. The cultivating of traffic engineering talents tends to be a multidisciplinary cross mode of traditional traffic engineering integrating machine, electricity, computer and information.

There have been long-standing contradictions such as rich curriculum but insufficient student interest and learning motivation, dual assessment requirements of teaching and research for teachers but difficulty in mutual assistance between teachers and students, and mismatch between requirements for cultivating student engineering abilities and teaching staff. A comparative analysis of the training models of transportation engineering majors in major domestic and foreign universities shows that transportation engineering is a major aimed at solving complex transportation system problems, requiring interdisciplinary intersection and integration[2]. In terms of curriculum design, foreign universities focus on offering a wide range of elective courses, while domestic universities focus on offering comprehensive professional courses[3-5]. In the previous research, there are new curriculum systems from the perspective of adjusting

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professional teaching objectives and graduation requirements , reform of professional curriculum textbooks, construction of practical teaching platform[6], and introduction of multi-disciplinary background industry talents[7] for cultivating new talents.

In this paper, a new talents cultivating method guided by projects is explored. By the method, it can not only mobilize student's enthusiasm but also promote student's learning, teacher's teaching and scientific research to help each other under the existing training mode. Taking the 'Portable Traveled Surface Roughness Test System' project carried out by the authors in the traffic engineering major of Wuhan University of Science and Technology as example, this paper introduces the training method of transportation engineering compound talents aided by micro major and how the project iterative development helps student and teacher growth.

2. TEST PRINCIPLE OF TRAVELED SURFACE ROUGHNESS AND PROJECT TRANSFORMATION METHOD

Pavement roughness is an index to detect the change of pavement elevation. It reflects the comfort, safety and economy of road operation, so it is one of the key indexes of road pavement surface. There are many detection methods, as shown in Figure 1.

a. Continuous eight-wheel road roughness meter

b. Leveling instrument

c. Three-meter ruler

d. Bump integrator

Fig 1 Pavement roughness detection methods

The manual measurement method is simple in equipment and low in cost, but it is inefficient, affects traffic, and is not suitable for road maintenance inspection after the road opened to traffic; the laser roughness meter has the advantages of high efficiency, high accuracy and not affecting traffic, but the cost of equipment is high. The development of road roughness detection equipment with convenient use, low cost and good accuracy is very important. Based on this, we firstly studied the test principle of pavement roughness and then carry out project transformation. The process is shown in Figure 2.

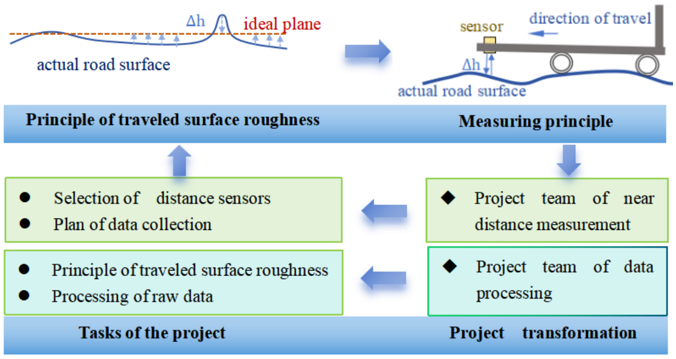


Fig 2 Test principle of travelled surface roughness and the project transformation process

The traveled surface roughness is the vertical deviation of the road surface relative to the ideal plane.We firstly analyze the testing principle, then transform the project according to different tasks, and finally formulate project tasks according to project objectives, recruit project team, and carry out the projects. Because the decomposed tasks are relatively simple, sophomores can successfully complete.

3. DEVELOPMENT OF THE TEST SYSTEM AND THE PROCESS OF PROJECT ITERATION

After team recruitment, the projects are carried out according to the tasks. In this process, the near distance measurement project team investigates various distance test sensors, chooses the specific model of the sensor, determines the data acquisition scheme, completes the data acquisition, transmission and storage problem. The data processing team learns the principle of traveled surface roughness, analyzes the error sources of the collected data, learns data processing software, and converses the sensor's signal to traveled surface roughness. The process is shown in Figure 3.

The team selects the Sharp GP2Y0A21 infrared sensor, which has a detection distance of 10cm-80cm, an operating voltage of 4.5-5.5V, an average power consumption of about 30mA, and a reaction time of 5ms. It has strong adaptability to background light and temperature and supports Arduino development. The vibration of the vehicle during the movement will affect the test results. When measuring the vibration displacement in the vertical direction, we find that there is no sensor that can directly detect this small displacement. Therefore, it is more feasible to find a suitable speed sensor or acceleration sensor. After obtaining the velocity or acceleration in the vertical direction, the displacement generated by the vertical vibration during the movement is obtained through the integral operation as the distance compensation. After comparing various accelerometer, the MPU-6050 acceleration sensor is selected. The sensor is cheap and can output 3-axis acceleration. It supports acceleration tests of ± 2g, ± 4g, ± 8g and ± 16g, and is compatible with the Arduino platform. Finally, the team use the Arduino development board to complete the data acquisition and output, using a laptop to receive test data and to power the entire system.

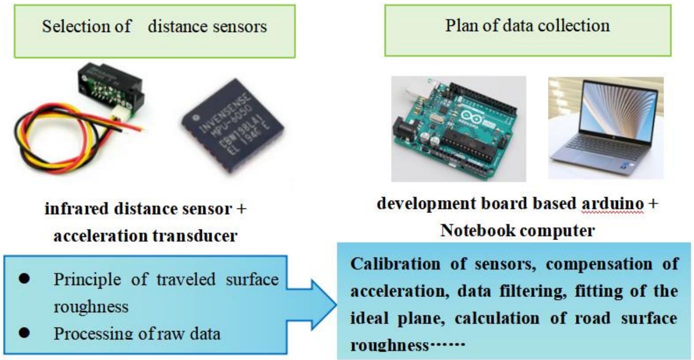


Fig 3 The project execution process

The data processing team develops a sensor calibration scheme. The sensor calibration is to convert the output voltage value of the infrared sensor to the corresponding elevation of the probe to the road surface. Repeated tests are performed at intervals of 50 mm at heights of 100 to 500 mm from the horizontal plane. Fifty sets of data are recorded at each height, and the average value is taken as the voltage value at each height, and then mathematical formulas are used to fit the data. Four fitting models are tried and the corresponding root mean square error is calculated. The results are shown in Table 1. In this figure, y and x units are centimeter and 10-bit voltages, respectively. After comparison, the type of fitting formula y = a / (x + b) + c, has the best fitting effect and the fitting curve is shown in Figure 4. Finally, the best fitting formula is:

$$y = \frac{1858}{x-122} + 6 \tag{1}$$

Table 1 The voltage-distance fitting results under different models

Data	Fit type	SSE	R-square	DFE	Adj R-sq	RMSE
y vs. x	a/(x+b)+c	6.4147	0.9957	6	0.9943	1.0340
y vs. x	a/x	234.0291	0.8440	8	0.8840	5.4087
y vs. x	a/(x+b)	21.1148	0.9859	7	0.9839	1.7368
y vs. x	a/x + b	107.0037	0.9287	7	0.9185	3.9098

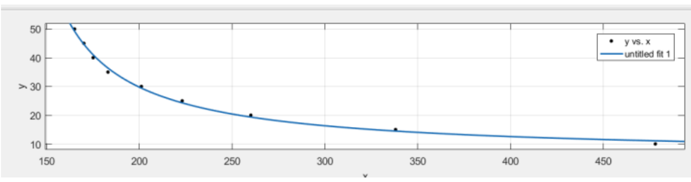


Fig 4 Curve of the best fitting model

After completing sensor calibration, the data processing team completes data analysis according to the process shown in Figure 5.

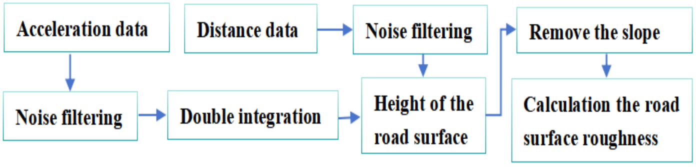


Fig 5 Data analyzing process

Among them, the analysis and calculation of traveled surface roughness is referred to the transportation industry standard JTG3450-2019 Field Test Methods of Highway Subgrade and Pavement. The roughness calculation takes a length of 100m as a calculation interval, and calculates the standard deviation σ_i of the displacement value (di) collected in the interval according to formula (2), that is, the smoothness of the interval, measured in mm, retains a decimal number .

$$\sigma_i = \sqrt{\frac{\sum di^2 - (\sum di)^2 / N(\sum di)^2}{N-1}} \quad (2)$$

In the formula : σ_i is the flatness calculation value (mm) of each calculation interval;

Di is the concave and convex deviation value (mm) of the road surface collected at a certain distance, taking 100 m as a calculation interval;

N is the number of test data that is used to calculate the standard deviation.

Finally, during field testing, an asphalt concrete greenway in the school is tested, and the standard deviation is about 1.8mm, which is less than 2.0mm in line with the standard requirements.

The above process is the first iteration of the project. Two project teams are formed by 10 sophomores and juniors, and the whole process of project planning, research, implementation and summary is completed in about one year. These ten students are all majoring in traffic engineering. Their training plan does not include courses related to electronics or testing. However, through the study of related online micro-courses, they have the ability to initially solve more complex cross-disciplinary engineering problems. The implementation of the project derives and supported two graduation design topics.

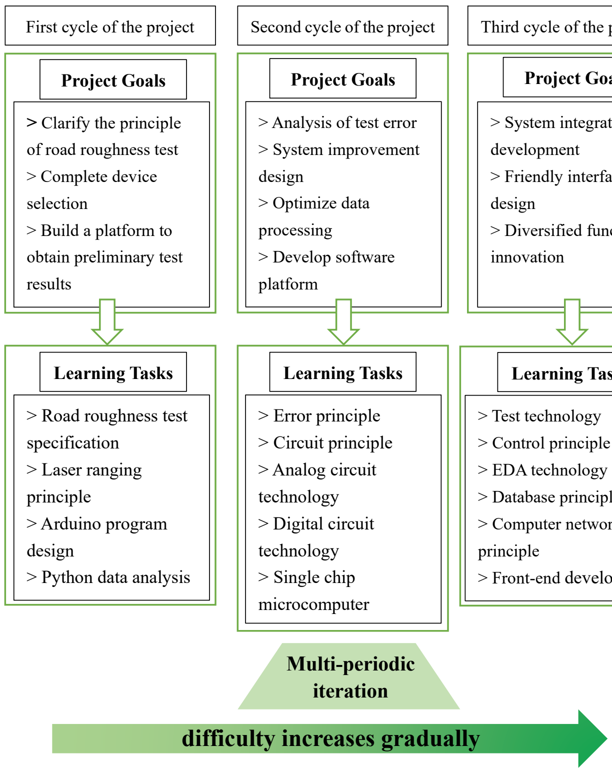


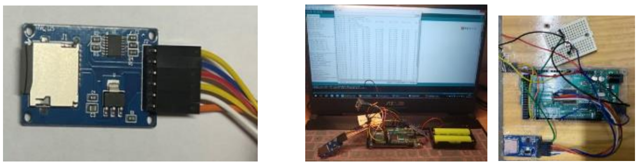
Fig 6 Iteration of the project

The second and third iterations of the project are still the process of problem raising, principle analysis, project transformation, team recruitment, project task decomposition, micro-professional assisted learning, task implementation and goal achievement. In the second and third iteration of the project, the team members have the previous round of members, which play the role of inter-generational transmission of knowledge and can accelerate and promote the further implementation of the project. Figure 6 is the process of project iteration.

After the third iteration, the test system is equipped with portable functions, which means the system has the features of small-volume, self-power, bluetooth data transmission, data storage and process, and so on. They are shown in Figure 7.

a.power supply module

b. bluetooth module



c. MicroSD Card Adapter d. Integrated test of the system

Fig 7 The developed test system after the third iteration

It can be seen that the cultivation of projects is a process from easy to difficult, from engineering application to application innovation. The implementation cycle of the project is relatively long, especially in stages that require a large span of professional knowledge for learning and application. A single cycle may not be enough and requires multiple iterations. But each cycle has phased task goals, which are achievable. How to promote the inter-generational transmission of learned knowledge and accumulated engineering experience among students is the key to continuously improving project quality and improving student engineering abilities. If a project is only carried out in one grade, or if the same engineering project flows through multiple grades without experience transmission, it cannot convert the knowledge learned by predecessors into the foundation for later learners. Therefore, each cycle of the project is jointly participated by students from sophomore to senior years. Among them, the sophomore students are newly recruited students, whose main role is to perform smaller and simpler tasks in the project and follow the learning of senior students; The third year students are transferred from the previous project and have already been exposed to the project and started learning new knowledge in the second year. Currently, they are in a state of in-depth learning and partial output; Senior students, on the other hand, rely on their graduation project to tackle key issues that arise from the project. In the project of "Portable Traveled Surface Roughness Test System", the first cycle recruited a team of 7 sophomores, 3 juniors. After the first cycle ends, four sophomore members persist until the next cycle; of three junior members, one successfully took the postgraduate entrance exam in computer science which crosses majors, and two took the postgraduate entrance exam at our university to continue the hardware and software development research of this project; Two senior students took graduation design in hardware integration development and data processing based on Python. The development process of senior students was supported by their sophomore and junior classmates, and their achievements also provided good feedback to their sophomore and junior classmates.

During the execution of the above project, students need to continuously learn new knowledge across different majors. Thanks to the abundant learning resources available online, differences between majors have not become barriers that are difficult to overcome. However, as the project progresses from demonstration development to product development, the lack of professional basic knowledge has become a ceiling that is difficult to break through. For example, after the initial completion of the software and hardware integration development of the system, the test results showed instability, and the lack of basic knowledge prevented students from analyzing the reasons for inaccurate measurement results. This requires cross disciplinary knowledge learning of the system to establish basic professional literacy. Micro majors have become a good supplement. "Micro major" is a series of micro course packages designed to meet the latest development needs of society. Through short-term concentrated training, students are equipped with strong professional competitiveness and abilities. This project draws inspiration from the micro professional model and refers to the training programs of "Circuit and Systems", "Computer Technology", and "Measurement and Control Technology" majors from other universities. It searches and screens network resources to form a micro professional course directory, and conducts systematic learning under the supervision of the supervising teacher.

4. CONCLUSIONS

Different from mature university student innovation and entrepreneurship projects, engineering training projects, industry-university-research projects and competition instead of practice discipline competition projects, the projects constructed in this paper drives the inter-generational transmission of knowledge through project circulation, deepen the project development through inter-generational knowledge transmission, and promotes students micro-professional learning with the in-depth development of projects. So as to achieve cross disciplinary and composite talent cultivation under the guidance of mentors, as well as the cultivation of composite talents to feed back the research and innovation of mentors. The full cycle of project iterations are introduced. From the execution process of the above project, it can be seen that the execution cycle of a project can drive about 10 students to participate in the learning and application of cross disciplinary knowledge, effectively playing the promoting role of micro majors in the cultivation of composite talents. The execution process of the project provides a new reference path for the cultivation of versatile talents in transportation engineering.

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