Research on the Teaching of "Sensor" Integrating Innovation and Entrepreneurship Education

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Abstract
Sensor technology, communication technology, and computer technology are the three pillars of information science and technology. The content of the sensor course is complex and involves a wide range of knowledge, which leads to students confused and not knowing how to apply the knowledge. The deep integration of professional education with innovation and entrepreneurship education attracts extensive attention. It solves the application problem of professional expertise and can cultivate students' interdisciplinary thinking and train comprehensive talents for society. This paper mainly studies the Sensor curriculum teaching methods based on the concept of innovation and entrepreneurship and the Project-Based Learning (PBL) method to cultivate students' comprehensive literacy.

Keywords: *Sensor course, PBL, instructional design, professional education, innovation and entrepreneurship education*

1 INTRODUCTION

According to the National Bureau of Statistics Data, there were 8.265 million ordinary college graduates in 2021, which was 293000 more than that in the previous year, and the year-on-year growth rate was 3.7%. In 2021, 750.64 million people were employed, which was 4.12 million fewer than the 750.64 million in 2020. Employment has shown a downward trend (Figure 1). In order to alleviate the employment problem of graduates, the Ministry of Education pointed out in the 2022 work points that the following measures should be taken: implement employment and entrepreneurship promotion actions, establish an employment and entrepreneurship promotion mechanism, and promote innovation and entrepreneurship to drive employment.

In the teaching of the Sensor course, PBL method is used to enable students to understand why this professional course is studied and how to apply this profession course into their career development. In this way, the integration of professional education with innovation and entrepreneurship education is realized, and students' personal value and social value are brought into full play to promote "mass entrepreneurship and innovation" [14].

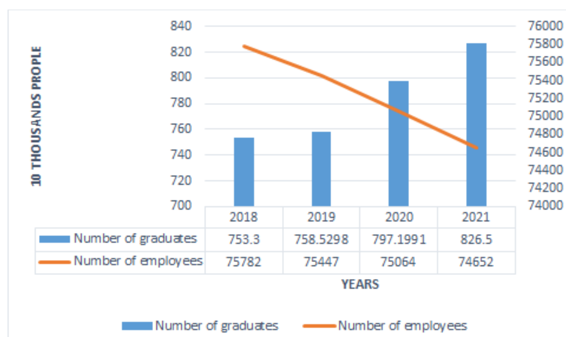

Figure 1: Number of graduates and employees from 2018 to 2021

2 INTEGRATION OF PROFESSIONAL EDUCATION AND ENTREPRENEURSHIP EDUCATION

A representative definition of innovation and entrepreneurship education is that by cultivating students' comprehensive qualities, including entrepreneurial awareness, entrepreneurial thinking and entrepreneurial skills to build an education system that enables educated people to have innovation and entrepreneurship abilities (MA and BAI, 2015). Besides, professional education is usually regarded as general education.

The relationship between them can be explained from theory and practice. In theory, they take the cultivation of

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comprehensive talents as the starting point. Innovation and entrepreneurship education is embedded in the talent training scheme of professional education and is an organic component of professional education [4]. Professional education provides a theoretical and practical basis for innovation and entrepreneurship education with its knowledge and skills reserve. In practice, innovation and entrepreneurship education takes the cultivation of innovative spirit, innovative consciousness, and entrepreneurial ability as the core quality guidance the development and exploration of disciplines and professional fields, as well as the expansion and integration of interdisciplinary in this professional field.

The integration of specialty and innovation takes the practice of American colleges and universities as the prelude. At present, many researchers in China are exploring macro-level integration methods, mechanisms and environments such as the "three helices" education integration model [18]; "Talent innovation culture achievement" four spiral paths [9], the Internet plus school education mode of innovation and entrepreneurship [16]. Most of them carry out top-level design, only a small part of the micro-level curriculum teaching design. Many student-centered teaching methods, such as CBL(case-based learning), experience teaching method, and PBL, provide teaching framework ideas for integrating specialty and innovation. Moreover, PBL effectively integrates professional and creative teaching because of its real situation and complete production.

3 PROJECT-BASED LEARNING

PBL is student-centered, it can effectively solve the problems such as why students learn this course and what is the application value of learning this course. It has advantages [6]: (1) give full play to students' autonomy; (2) emphasize interdisciplinary knowledge; (3) based on the actual production and life; (4) conducive to cultivating team spirit and cooperation ability; (5) conducive to cultivating students' innovative spirit; (6) conducive to cultivating students' problem solving ability and practical ability; (7) conducive to helping students master the methods of learning. The essential elements of PBL are shown in Figure

- Element 1: the content is required to be based on the reality or actual production and life, and be complete and in line with students' interests and characteristics;
- Element 2: the activity requires a certain degree of challenge, constructiveness, and sustainable inquiry;
- Element 3: the situation is a specific learning environment that promotes students' team consciousness and cooperative spirit;
- Element 4: the production is the final work output, and the form of expression is not unique, it can be a report PPT, or molded works, papers, etc.

Figure 2: PBL teaching elements.

The teaching process of PBL is usually divided into six steps: project selection, plan formulation, activity exploration; work production; achievement display and communication, and evaluation.

4 PROJECT CASE

4.1 Project introduction

With the popularity of national fitness awareness, the enthusiasm of national sports is rising; moreover, Beijing Winter Olympic Games launched this year have aroused another wave of sports upsurge. However, we should consider the sport's risks caused by improper movements while exercising. In competitive competitions, we should pay more attention to the details of movements, so as not to miss the champion. At the same time, the movement posture monitoring of the athletes can be guided based on ergonomics, and try to avoid non-standard movements or unnecessary sports injuries caused by excessive use of muscle groups. The ultimate purpose of this project is to design a sensor product that can detect human posture, which is used to collect motion data, describe motion trajectory, force point, and other data, and enable students to understand the sensitive mechanism of resistance strain sensor and sensing signal detection method during the activity.

4.2 Making a plan

A lesson plan can ensure teaching tasks are predictable and completed correctly. During the process of activities, teachers gradually change from "professors" to "participants," and students change from "passive listeners" to "active participants." The whole planning process is shown in Table 1 below.

Table 1: Preset plan.

Stage	Stage	Organizational form
Phase I	Accumulation of necessary knowledge: principle of resistance sensor, main, characteristics, sensing signal detection circuit, etc.	(1) On-line class: MOOC, etc. (2) Off-line class (3) hybrid class: flipped class, etc.
Phase II	Project analysis: feasibility analysis, demand analysis, overall structure, analysis, hardware analysis.	(1) Group cooperation (2) discussion method
Phase III	Find or raise problems, analyze problems, collect data, propose preliminary plans.	(1) Group cooperation (2) discussion method (3) discovery method (4) question and answer
Phase IV	Innovation Discussion	(1) Discussion method (2) brainstorming
Phase V	Selection of tools and schemes, production results display and communication, and evaluation.	(1) Group cooperation (2) discussion method

4.3 *Activity exploration*

During the activity, teaching support is built for students to optimize the teaching effect. The preset guiding questions are shown in Table 2 below.

Table 2: Question presupposition

Process	Preset problem	Remarks
Feasibility analysis	(1) Technical analysis: research status at home and abroad (2) resource analysis: conditions of existing	
Requirement analyse	(1) How to choose the contact material? (exercise requires flexion, extension, and the muscle or skin is stretching or contracting.) (2) What are the requirements for the measurement range, sensitivity, radiation frequency, penetration? (3) How to determine the measurement position?	(1) Let students know what a flexible sensor is, and what characteristics it has (2) Let students analyze the stress range of the pressure sensor; sensitivity; response time; circulation stability (3) Students can choose plantar, knee, lumbar and abdominal core radial artery, and other parts for monitoring
Overall structure analysis	How to select the system structure according to the measurement node?	

Hardware design	(1) How to choose flexible materials ? (2) How to design the measuring circuit according to the motion principle ?

4.4 *Production works*

It's time for students to design and complete the production. The whole module design includes a sensor, processing, and analysis module. In addition, the wireless operation needs the support of a regulated power supply, as shown in Figure 3 below.

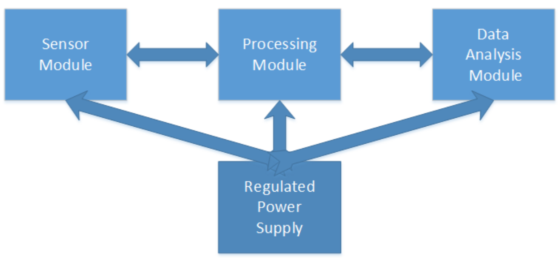

Figure 3: Design module diagram.

4.4.1 Sensor module

The principle of the resistance sensor is The Strain Effect. When pressure or tension acts on the sensor, itwill deform and change its resistance. The resistanceformula is,

$$R = \rho \frac{l}{S} \tag{1}$$

Among ρ is the electrical resistivity, l is the length of the electrical material, and S is the cross-sectional area. Take logarithms at both ends of the formula at the same time.

$$\ln R = \ln \rho + \ln l - \ln S \tag{2}$$

The formula obtained by differentiating formula is,

$$\frac{dR}{R} = \frac{d\rho}{\rho} + \frac{dl}{l} - \frac{dS}{S} \tag{3}$$

Take the wire type as an example, where $S = \pi r^2$ is the wire radius, and the relative change of cross-section under stress can be expressed as follow,

$$\frac{dS}{S} = 2\frac{dr}{r} \tag{4}$$

dr/r is the radial strain, recorded asε_r, indicating the relative change of radius, and the axial strain is $\varepsilon = dl/l$. According to the definition of $\mu = -\frac{\varepsilon_r}{\varepsilon}$, the following formula can be obtained,

$$\frac{dS}{S} = 2\varepsilon_r = -2\mu\varepsilon \tag{5}$$

Therefore, the relative change of resistance can be expressed as follow,

$$\frac{dR}{R} = \frac{d\rho}{\rho} + (1 - 2\mu)\varepsilon \tag{6}$$

To sum up, part of the resistance change comes from stress, and the other part comes from the structural changes inside the semiconductor material. As for the preparation process of the piezoresistive flexible sensor, traditional process generally adopts filling, sandwich, and adsorption structures [17]. The most important parts of the flexible sensor are conductive materials and a flexible substrate. The comparison of common types of conductive materials is shown as Table3.

Table 3: Comparison of physical properties between three conductive materials. [3]

Material category	Electrical resistivity (Ω· cm)	Physical properties
Graphene	10^{-6}	low cost; low density; good electrical conductivity high surface;
Ag	10^{-5}	high cost; large density; better electrical conductivity; strong corrosion resistance
PPY	1 ~ 10	low density; pretty compatibility; higher electrical resistivity

The flexible substrate enables the sensor to stretch and make it more fit the human body surface. PDMS (polydimethylsiloxane), the chemical formula is $(C_2H_6OSi)n$. It's usually used as the base material.

Device structures based on conductive materials and flexible substrates can be roughly divided into planar thin-film, rough surface, and three- dimensional porous structures. Figure4 shows that the flexible pressure sensor based on the three- dimensional porous structure can maintain high sensitivity in a relatively wide stress response range [2] [7] [8] [11] [13] [20].

Different positions and postures have different requirements for the sensor's detection range. For example, the plantar pressure loads of different postures are shown in Table4.

The following strain gauge structure (Figure5) and flexible three-dimensional tactile structure (Figure6) can be used to reference the sensor structure.

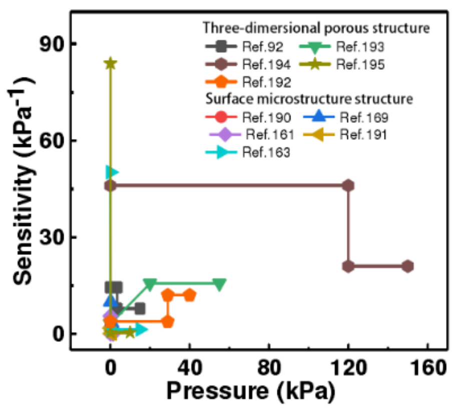

Figure 4: Comparison of sensitivity and stress monitoring range of flexible pressure sensor based on surface microstructure and three-dimensional porous structure.

Table 4: Plantar pressure under different posture [21].

Posture	Research object	Sole pressure (kPa)
Stand	Healthy youth	150-310
	Diabetic	>600
Walk	Healthy youth	30-935
	The old	170-350
Run	Healthy youth	30-300
	Runner	120-360
Javelin throw	Athletes	150-360

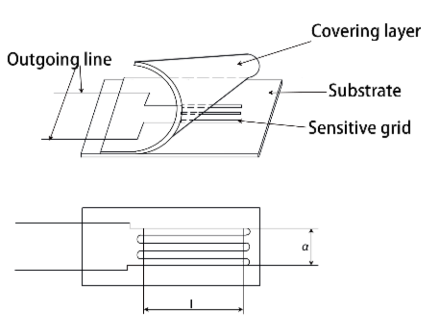

Figure 5: strain gauge structure.

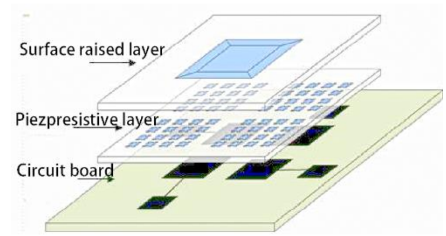

Figure 6: flexible three-dimensional tactile structure [12].

4.4.2 Processing module

It involves the selection of microcontrollers in the design of micro control units, the design of hardware circuit systems such as measuring circuits. The relationship between metal resistivity and volume is introduced to further deduce (6), which is finally expressed in incremental form as $\frac{\triangle R}{R} = K_S \cdot \varepsilon$, where K_S is the strain sensitivity coefficient of metal, and the resistance change adopts the DC bridge measurement circuit shown in Figure7.

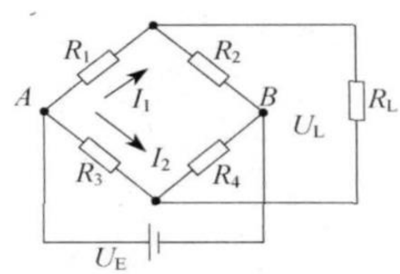

Figure 7: DC bridge [1].

The general form of the measured bridge output voltage is,

$$U_L = \frac{R_1}{R_1 + R_2} U_E - \frac{R_3}{R_3 + R_4} U_E = \frac{R_1 R_4 - R_2 R_3}{(R_1 + R_2)(R_3 + R_4)} U_E \quad (7)$$

4.4.3 Data analysis module

The obtained data is transmitted to the host computer and is analysed. The artificial neural network algorithm can be used to complete the tasks of identification and characteristic analysis. For example, the RBF neural network (Figure8) can detect the relationship between the contact position and its force, and the RBF neural network can be trained to continuously modify the parameters to obtain the final linear relationship (Figure9) [19]. In addition, there are texture recognition [10], contact shape recognition [5], three-dimensional force decoupling [15].

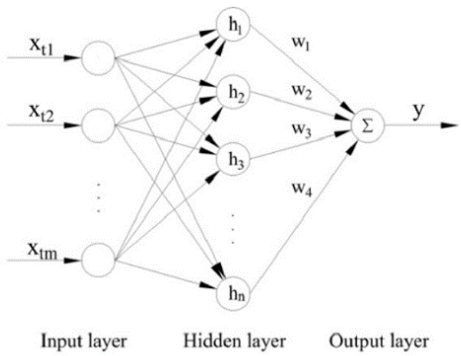

Figure 8: RBF neural network schematic diagram.

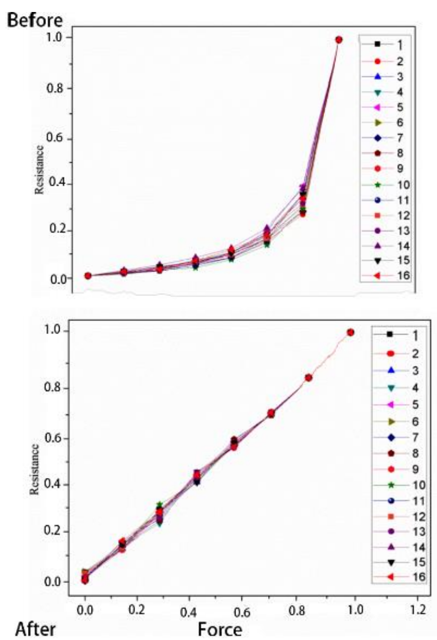

Figure 9: Training renderings.

4.5 *Achievement display and communication*

The students' problems and solutions in the project process should be the focus of communication; meanwhile, innovative and entrepreneurial ideas should be taken as an important part of the presentation. Students are encouraged to raise questions and optimize plans to cultivate their critical spirit, scientific, rigorous attitude, creative integration thinking, innovation, and entrepreneurship awareness.

4.6 *Evaluation*

Multi-dimensional evaluation should be carried out on students and their project achievements. The ultimate purpose of the evaluation is to drive students to grasp knowledge and promote them to innovate and apply. Therefore, students' knowledge mastery should be strictly evaluated, while their innovation and achievements should be loosely evaluated to achieve the effect of encouragement. Students, groups and teachers are multi-subject for grade assessment. The evaluation criteria for teachers are as follows Table5.

5 CONCLUSIONS

Innovation is not only the driving force of social development but also the quality requirements of young people in the new era. This paper discusses the implementation process of the PBL method combined with the sensor course and motion detection project. Through making plan, activity exploration, production works, display and communication, evaluation and other processes, students can acquire knowledge and expand their capacity. The teaching process focuses on reflecting students' subjectivity, giving full play to students' initiative, and cultivating creative consciousness and innovative thinking. Ultimately, it is promising to realize the collision between the project and students' own innovative and entrepreneurial ideas.

Table 5: Teacher evaluation form.

Project Name					
Evaluation content	Excellent	Good	Pass	Fail	Proportion (%)
Mastery of theory					30
Practical operation ability					30
Emotional attitude					10
Creative					10

thinking					
Personal evaluation					5
Group evaluation					5
Project report					10

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