Teaching an Optoelectronics Course Using Outcome-Based Education

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Abstract. To cultivate engineering talents who could meet the needs of social and economic and keep up with the pace of professional certification, it is necessary to reform the basic course of Optoelectronics, which is an important professional course of electronic science and technology major. Outcome-based education (OBE) is an advanced engineering education theory that is recognized by the world and has a complete theoretical system and practice mode. In this paper, we reformed the Optoelectronics course based on the OBE concept. First, we introduced the definition and characteristics of OBE, then we explored the applications of OBE in the Optoelectronics course from teaching strategy, experiment course, and examination mode. We discussed the teaching plan based on OBE in detail with the simulated solar cell experiment. This research has a certain role in the Optoelectronics course reform in our country, and it could also provide a new idea for the training of new engineering talent.

Keywords: Outcome-Based Education · Optoelectronics · Teaching Strategy · Experiment Course · Examination Mode

1 Introduction

Outcome-based education (OBE) is a kind of educational philosophy based on results. At the end of the educational journey, each student can achieve the desired outcome. The teaching and evaluation methods in the OBE concept are not unique, but the design and implementation of the course system should be carried out from the perspective of helping students achieve their goals [1, 2]. The concept of OBE has been widely applied in the world's education system. Australia and South Africa began to adopt the concept of OBE as early as 1990, the United States began to implement the OBE program in 1994, Hong Kong began to apply OBE to university education in 2005, and Malaysia implemented the policy of OBE in all its public-school systems in 2008. Europe and even the European Union have turned their attention to OBE. In the Washington Agreement created in 1989, OBE was recognized by the international community, which agreed that OBE should be applied to the undergraduate engineering education system. In June 2016, China became a full member of the Washington Agreement, which means that

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China's professional certification standards for engineering education have been raised to the international level. It is of practical significance for our country to carry out engineering education reform based on the OBE concept. Optoelectronics is a basic course of the electronic science and technology major in higher education schools. It is also one of the introductory courses for optoelectronics engineers. As the internal driving force of social development, engineering talents have a profound impact on the level of scientific and technological development and the quality of people's life in China [3, 4]. To better train engineering and technical talents and keep up with the pace of professional certification, the teachers of our college have carried out the reform and exploration of the course of Optoelectronics based on OBE. We explored the applications of OBE in the Optoelectronics course from teaching strategy, experiment course, and examination mode. Especially in the experimental course part, we took the simulation solar cell as an example to introduce the application of OBE in the teaching plan. This study has a certain role in the Optoelectronics course reform in our country, and it could also provide a new idea for the training of new engineering talent.

2 Outcome-Based Education (OBE)

Unlike traditional education models, which tend to focus only on what a school can offer students, OBE focuses on helping students identify and achieve target outcomes. What are the Outcomes exactly? Target outcomes are the explicit learning outcomes that we want students to achieve through effective learning experiences. They are not values, emotions, attitudes, or mental states. They are what students can do with what they know or have learned, that is, they can concretely apply what they have learned to practice. This means that learning outcomes are actions and performances that embody and reflect students' ability to successfully use theories, information, ideas, and tools. It is a major step for students to use what they know to do important things, not just to know knowledge. Therefore, educators must use observable action language, such as description, interpretation, design, or production, in defining and designing target outcomes, rather than vague or hidden untestable processes, such as knowing, understanding, believing, and thinking. In addition, the concept of target outcomes should be applied to the final stage of a student's school career, rather than being limited to a certain period or period of time in the course. In this way, both students and teachers will have a final goal, which they can work towards and accumulate learning and teaching experience.

The biggest difference between the teaching system based on the OBE concept and the traditional teaching system is mainly reflected in the following four aspects. (1) Every step of curriculum design, teaching strategy, evaluation, and performance standard formulation and implementation based on the OBE concept teaching system is centered on clear learning outcomes [5]. In the OBE model, curriculum, teaching, and assessment should be flexible to achieve a clear "purpose" of learning. In contrast, traditional education systems already have a largely pre-defined curriculum structure that includes assessment and grading systems, and the construction process is not usually practiced around clearly defined outcomes expected of all students; (2) The time required in the learning process is determined by the needs of teachers and students. Within reasonable time limits, time is used wisely to maximize the benefit of all students [6]. But the

traditional teaching system is, on the contrary, learning time is fixed, which is a rigid constraint for teachers and students. Schedules and calendars control students' opportunities for learning and success; (3) In an OBE-based teaching system, the standards are clear and all students know what the basic requirements are. Everyone has a chance to get the results they want [7]. But in the traditional education system, opportunities are limited. It is often taken for granted that the best students get good grades and that the worst students fail. (4) The OBE-based education system focuses on cultivating and improving students' learning ability to help them reach the peak of their final ability before graduation. The current system is the complete opposite, where students are tested and permanently graded for each part of the course, and mistakes become part of a student's record, accumulating reminders of past mistakes. Over time, those who are fast and consistent will have better results and records. Those who were slower never had a chance to catch up because they were held back by a record of errors that they couldn't erase before, or what we often call "breaking the can". In general, OBE has the following four criteria: setting clear and well-defined target results; encouraging and helping students to increase their chances of learning success; believing that all people can achieve the goal results and practicing with the goal of final results [8]. Successful OBE practitioners should consistently, systematically, rhythmically, creatively, and simultaneously follow these 4 guidelines.

3 Exploration of the Teaching Strategy of Optoelectronics Under the Concept of OBE

The course Optoelectronics covers a lot of theoretical concepts and complex formulas. Therefore, in the traditional teaching process, the teachers often put most of the class hours on the explanation of theoretical knowledge but ignore the connection with life practice. In addition, most of the current science and engineering teachers have a doctor's degree, and they are usually engaged in basic research work during their study, and the research field is relatively narrow. This makes it difficult for some teachers to integrate scientific knowledge into classroom teaching. Finally, classroom teaching becomes the forcible indoctrination of knowledge by teachers and passive acceptance by students, which makes the classroom boring, students' interest in learning decreases, and the classroom effect is not ideal, which results in a large number of failures in exams. Optoelectronics under the OBE concept model advocates that students should change from passive learning to active learning, and apply the knowledge to practice. Course design is often based on real topics or open-ended tasks, challenging and providing a platform for collaboration between students and teachers or students. In addition, the 5-step learning cycle of participation, exploration, explanation, elaboration, and evaluation can be adopted to help students learn and get the target results. Especially in the participation and exploration links, students can participate in the practice by themselves, and then start the formal learning with questions, which often can get twice the result with half the effort.

4 Exploration of Experiment Course of Optoelectronics Under the Concept of OBE

Optoelectronics is a highly practical course, so the experimental courses are as important as the theoretical courses. The OBE concept advocates a learning model based on situational cognition, which can enhance students' sense of engagement and subjective initiative. This model can be divided into three stages: modeling (demonstrating how to do something), mentoring (providing opportunities for practice and feedback), and finally fading (gradually removing help from students). The experimental course of Optoelectronics under the concept of OBE tries to break the traditional verification or "textbook" teaching mode. Instead of students mechanically repeating what teachers or textbooks say or do, it should actively create a learning atmosphere, provide a platform for students to show, and increase students' participation and interaction. For example, after learning the Fundamentals of photoelectric detection technology in Chapter 6, we can design an experiment with a solar cell. Students can form a study group, mutual communication, comprehensive use of knowledge to design the solar cell, through the experiment to verify their ideas, explain the reasons, and finally show their results, self-evaluation, mutual evaluation, and teacher comments. The teaching process is shown in Fig. 1.

The OBE teaching plan and goals are shown below. (1) Experiment preparation stage (one week). The teacher gave a class on the basic concepts, the safety common sense, and the environmental protection concepts. Students self-study and discuss the basic theory, reagent properties, instrument operation method, and simulation software. Students designed the experiment independently after searching the literature. In general, the structure of perovskite solar cells is a planar layered structure, from bottom to top: glass substrate (FTO glass), electron transport layer, perovskite layer, hole transport layer, and electrode layer. Light passes through a transparent, conductive glass and hits the perovskite absorbing layer. Photons with energies larger than the band gap width of perovskite are absorbed and excited to produce electrons and conductive holes. Carriers are separated by the perovskite layer, electrons pass through the electron transport layer to the FTO, conductive holes pass through the hole transport layer to the metal electrode, and then through the external circuit to form a loop. According to the volt-ampere characteristic curve of the photocell, four output parameters describing the solar cell can be obtained. Open-circuit voltage (V_{oc}). $R = \infty$, $I = 0$, that is, $I_L = I_F$. Substitute $I =$

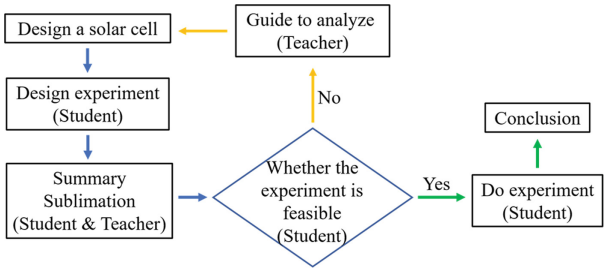

Fig. 1. Teaching process with OBE.

0 into the current and voltage equation of the photocell, the open-circuit voltage is: Voc $= \frac{kT}{q}\ln(\frac{I_L}{I_S}+1)$; ; Short-circuit current (I_{sc}). If the PN junction is shorted (V = 0), so IF = 0, then the resulting current is the short-circuit current Isc. The short circuit current is equal to the photogenic current, namely: $I_{sc} = I_L$; Fill factor (FF). It represents the percentage of the rectangular area corresponding to the maximum output power point in the rectangular area composed of V_{oc} and I_{sc}. Solar cells with good characteristics are those that can obtain high power output, that is, those with the large products of V_{oc}, I_{sc}, and FF. For cells with suitable efficiency, the value should be in the range of 0.70–0.85. The greater the FF value, the greater the output power of the solar cell. The value of FF is always less than l; Energy exchange efficiency (η). It represents how much of the incoming solar energy can be converted into effective electrical energy. Because of the impact of COVID-19, we used software modeling. The structure of solar cells (PN junction) will be simulated first with ATHENA, followed by solar energy simulation with ATLAS. Some basic properties of battery: V_{oc}, I_{sc}, spectral reaction, and considering the effect of adding anti-reflection film on spectral reaction. (2) Experiment implementation stage (two weeks). The students do experiments independently and teachers provide the necessary help. In the simulation experiment of a solar cell, the influence of external light sources will be taken into account. They could choose monochromatic light and multispectral light. They could define the mesh, the substrate, the deposit oxide thickness, the ion implantation forms, the annealing treatment, the electrode, the structure, light intensity, and et al. The open-circuit voltage and short-circuit current are obtained in the corresponding settings. Study the relationship between structure and performance to provide a basis for offline experiments. Then the students process data collection and write experimental reports independently. (3) Experiment summary stage (one week). Student exchanges and teacher comments. This part could help the student to improve oral expression and communication skills. Pre-class review and class discussion can help students integrate into the experimental atmosphere smoothly. Students are encouraged to design and complete experiments independently on the premise of fully understanding the purpose, content, and method of the experiment. Through OBE-based experimental courses, students can go through a learning cycle of observation and exploration, analysis and practice, interpretation and expansion, and have a deeper understanding of basic concepts, improve professional quality, broaden their horizons, and improve practical ability and teamwork ability.

5 Exploration of Examination Mode of Optoelectronics Under the Concept of OBE

The traditional examination mode of Optoelectronics is usually based on teaching or teaching materials. The examination mode is single, and most of the cultivated talents are exam-oriented. Students with high scores and low abilities cannot meet the needs of social and economic development. In the exploration of the examination mode of Optoelectronics based on the concept of OBE, we mainly tried the diversified form of "process assessment", adjusted the composition content and relevant proportion of grades, especially increased the quota of daily grades which mainly includes classroom performance, group discussion, daily homework, self-learning and introspective report,

experiment, and practice. We encourage students to "think out loud" by asking them to describe how they think about a particular situation or solve a problem, and explain their reasoning process, to discover their true learning state and learning difficulties, avoiding their rote memory of just repeating concepts. We will carefully design multiple-choice tests or questionnaires to analyze students' common spontaneous wrong answers, eliminate interference factors and find out the key problems. We encourage students to actively carry out self-diagnosis in the hope that they can reflect on their mistakes in homework, group discussions, review sessions, and exams, learn from them and avoid making the same mistakes again. Students are encouraged to display their learning or practice through online learning spaces. We also encourage and support students to participate in competitions at or above the provincial level, or participate in industry-university-research and enterprise activities. If students win prizes in competitions at or above the provincial level or get rewards from the enterprise, the course can be exempted from the exam with a good score, or they can be assessed according to normal procedures and scored according to the actual score. Finally, we conducted a questionnaire survey to analyze students' satisfaction with OBE teaching. Students gave their responses out of five options for each question, ranging from strongly agree (5) to strongly disagree (1). The results were shown in Table 1. In general, the students felt that the OBE was helpful and improved their motivation to learn the course.

Table 1. Optoelectronics course satisfaction questionnaire based on the concept of OBE

		Average	SD
1	I like the optoelectronics course.	4.10	0.55
2	The new way of teaching increased my interest in the course.	4.05	0.83
3	I prefer to participate in online/offline discussions and interactions with teachers.	3.95	0.60
4	My overall impression of the optoelectronics course was very good.	4.15	0.81
5	I really like the optoelectronics course based on the OBE concept.	3.95	0.60
6	I can get help from teachers timely and effectively.	3.85	0.75
7	My grades have improved.	4.15	0.59
8	I can communicate well with the study group and cooperate with other members to complete the study task.	3.75	0.97
9	In the face of new problems, I can think independently, innovate methods and practice.	4.20	0.62
10	OBE helped me form a good habit of preview before class and review after class.	3.95	0.76
11	The teacher's evaluation of me and reasonable.	4.10	0.64
12	I can set clear learning goals in each class.	3.90	0.79

6 Conclusion

OBE is an advanced engineering education concept recognized by the world and has a complete set of theoretical systems and practical modes. In the field of engineering education, there are many problems with the Optoelectronics course, which is the fundamental course of traditional science and technology and cannot adapt to the demand of economic and social development, which needs to be reformed with OBE. This article mainly from three aspects of teaching strategy, experiment course, and examination mode, the traditional Optoelectronics course based on the concept of OBE reform and exploration, using the concept of OBE to drive the reform and development of related courses, closely follow the pace of professional certification, also hope to provide new ideas for related courses reform and cultivation of innovative engineering talents.

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