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Research on Online Teaching and Offline Course Construction for Power Electronics

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Abstract: Due to the impact of the novel coronavirus outbreak, universities have adopted online teaching and carried out remote teaching. With the improvement of the epidemic and the approaching of the new school year, the organic connection between online teaching during the epidemic and offline course construction after the epidemic is not only a challenge for tertiary education teachers, but also an urgent issue to be addressed. Therefore, the power electronics course is taken as an example to explore this connection.

Keywords: Power electronics; Online teaching; Course construction

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1. Introduction

At the end of 2019, there was an outbreak of a serious infectious disease caused by the novel coronavirus (2019-nCov), which spread from Wuhan to countries all around the world. All nations, including China, are currently fighting against this novel coronavirus pneumonia [1]. In order to stop the spread on campus and ensure the safety and health of both students and teachers, the start of the 2020 spring semester was postponed in all universities. In response to the impact of the epidemic on normal classes and classroom teaching in higher education institutions, the Ministry of Education (MOE) issued the "Guidelines on the Organization and Management of Online Teaching in General Higher Education Institutions During the Prevention and Control of the Epidemic" on February 4, 2020, requiring these institutions to make full use of online courses and high-quality online teaching resources at provincial and university levels [2] as well as to rely on various online course platforms and learning spaces at all levels to actively carry out online teaching activities, including online lectures and online learning, thus ensuring the progress and quality of teaching during the prevention and control period and realizing the effort of "suspending classes without stopping learning" [3].

Faced with the sudden variable of the epidemic, various universities have adopted online teaching platforms for emergency purposes, guiding university students through online platforms; furthermore, teachers of various disciplines have begun to use various online tools for distance learning [4]. Online teaching during the outbreak and curriculum development after the epidemic present a double test for these teachers. In the present study, the "Power Electronics" course was taken as an example to explore the organic connection between online teaching during the epidemic and course construction after the epidemic.

1.1. Course characteristics as the determinant of the method of delivery

In view of the different nature of each course, each course should be taught using a delivery method appropriate to the course. Teaching methods used, whether online or offline, the teaching strategies, and the content of the course are determined by the characteristics of the course.

Power electronics is a compulsory course for electrical engineering and automation majors. It is highly practical and has a short iterative technology cycle [5]. In addition, it carries significance in the curriculum of all majors. The course is highly theoretical, and its content is relatively obscure [6]. The concepts are complex and difficult to understand; thus, many students have a poor foundation. In addition to that, the class size is often large, with some majors comprising up to 200 people in a class.

Power electronics is an emerging technology covering three disciplines: electricity, control, and electronics. It is a compulsory core professional foundation course for electrical engineering and automation majors [7]. The course is offered in the first semester of the third year of university, with a total of 56 hours, which include 40 hours of theoretical study and 16 hours of practical learning. This course considers the knowledge of power electronics as the basis and focuses on two cores: power electronic components and power electronic circuits. The basic principles of power electronic circuits, control methods, application methods, and other contents are taught in this course. The course content is divided into four modules, namely power electronic devices, power electronic circuits, pulse width modulation (PWM) control technology, and applications of power electronic devices. The first module is the foundation of the course, the second and third modules are the main body of the course, and the fourth module is the depth of knowledge of the course.

The standards of the course, which define the competence and knowledge objectives to be achievable by students at a high level, present quality objectives with rich ideological elements [8]. The overall training objectives are as follows: enable students to master the characteristics of power electronics devices so as to develop the ability to select devices; enable students to master the ability to analyze circuits, outline the working principles of circuits, analyze the output waveforms of circuits, and understand the transformation process of electrical energy; enable students to understand the scope of application of technology in this field and its development trends as well as to establish a comprehensive knowledge system structure; develop students' ability to think independently, innovate, carry out scientific research, and climb up the ladder, as well as love their country and family in order to strengthen the country's technological strength. The objectives of the course consist of knowledge objectives, competence objectives, and quality objectives.

(i) Knowledge objectives

Appreciate the basic knowledge and concepts of power electronic devices; familiarize with the structure, operating principles, and calculations of various power electronic circuits; understand PWM control methods.

(ii) Competency objectives

Develop the ability to select devices, analyze circuit structures, and analyze circuit waveforms; solve typical applications of power electronics in commonly used electrical energy converters.

(iii) Quality objectives

Develop a scientific attitude of seeking truth from facts, a working style of exploration, and a spirit of innovation; cultivate scientific aesthetic and strive to discover the intrinsic laws of relevant professional courses; cultivate the ability to learn independently and firmly establish a dialectical materialist worldview.

Local universities adopt the "serial" curriculum structure of basic courses [9], professional basic courses, and professional courses, with each course forming a relatively complete but closed teaching system. The same objects of research, such as devices and modules, are often observed in various courses, focusing only on their application in the course instead of the interconnection and extension of the content of each course from the perspective of engineering practice. As a result, students are unable to develop systematic awareness of circuits, their knowledge becomes more fragmented, and they are less able to relate one idea to another. An exciting theoretical teaching process not only allows students to better grasp professional knowledge, but also stimulates their motivation and professional interest, encouraging them to engage in practical, in-depth practice, promoting the concepts of action with knowledge and seeking knowledge with action, as well as paving the way for practical teaching.

When it comes to specific knowledge from related courses, the courses are combined to review what has already been learned and re-explain it. Only with a profound understanding of the basics and the ability to integrate them can students appreciate the true meaning of rectifier and inverter parameters and analyze waveforms and phase change points independently. For example, before explaining about rectifier circuits and three-phase controlled rectifier circuits, the average and root mean square (rms) calculations as well as three-phase circuits are reviewed. In view of the link between this course and other courses, the summary and emphasis of specific knowledge points when constructing the course would lay a solid foundation for students to successfully learn this course.

2. Selection methods of teaching modes during the epidemic

The outbreak was an unexpected event, and online teaching was encouraged to minimize the impact of such an event. In essence, there are too many differences between online teaching and conventional classrooms. Both teachers and students may be affected by the changes to the environment in which they take lessons. If the methods and approaches used in online teaching are not chosen properly, they can affect the quality of teaching and talent development. The nature and characteristics of the course determine the mode of online education. The teaching requirements, syllabus, talent training objectives, *etc*. should be first clarified. Thereafter, it is necessary to be familiar with the available online teaching platforms and choose one or more online platforms that are suitable for the course.

Information-based teaching is not a technology [10], let alone a tool [11]; it is simply a change in teaching. Online teaching should not be technology-oriented and hardware-orientated, but rather teaching-oriented and software-oriented. It is not simply a matter of completing teaching tasks and carrying out lessons online, much less purchasing a bunch of hardware. At the heart of online teaching lies a change in teaching philosophy.

With regard to the curriculum, for courses related to programming language, there are many interactive perspectives [12], and at special times like the epidemic, live courses may be suitable. In such settings, students are led to intersperse the implementation of program code with the explanation of knowledge points. Students may find it easier to understand such online courses. As the course progresses, the functions implemented become more varied and interesting, thus enhancing students' interest in learning and motivating them to learn. For courses with abstract knowledge and obscure concepts, online courses that are identical to the course textbook and teaching content can be found on various online platforms, such as China MooTools, during the epidemic. Students are encouraged to learn theoretical knowledge first in class according to the teacher's rhythm; after a lesson or two, the teacher conducts a live class and interacts with the students to understand the difficulties they encounter and address them. The teacher then shares common real-life cases involving relevant course content to consolidate their knowledge and stimulate students' interest in learning.

According to the characteristics of the course, China University Massive Open Online Course website is used for online teaching, and the power electronics course offered by Fujian Engineering College is selected, taken as an online resource, and recommended to students. In view of the similarity between the online resource and the textbook and teaching content, the online resource is assumed as the teaching resource. Moreover, the video materials, course handouts, post-course quizzes, and examination system are ideal, the basic knowledge points are complete, and the learning management is convenient for online learning. After the students have learned two or three sections, a live interaction using online platforms such as Tencent conference and Zoom is carried out. The purpose of this interaction is, firstly, to strengthen students' understanding of knowledge points through problem orientation, develop their ability to apply knowledge, scientific research awareness, and scientific literacy, as well as improve students' self-learning ability and awareness for active learning; secondly, to emphasize key elements; and, thirdly, to provide common examples in life, concretize abstract problems, visualize boring problems, and make uninteresting problems vivid.

For example, in the first interactive live session, the teacher provides the textbook definition of power electronics, *i.e.*, a technology of transforming and controlling electrical energy using power electronics, and Wilson's definition of power electronics, *i.e.*, a technology that efficiently transforms, controls, and regulates electrical energy by static means, so as to change the form of input power into the desired form of output power [13]. The teacher then asks, "What is the transformation and control of electrical energy?", "What is the form of power that can be obtained?", and "What is the desired form of power?". Following that, students are actively guided to use what they have learned from the Massive Open Online Course platform to answer the questions. However, due to the large number of students in class, the network can be a little laggy. The teacher interacts with the students at times, acting like a webhost, saying things like if you can understand, type "1"; if you have doubts, type "2"; if you do not understand at all, type "3." At this point, we will see a rapid data growth in the chat box. This kind of live interaction is "alive." It is not just a lecture, where one side may be listening intently, whereas the other may be doing something unrelated to the course due to boredom or poor understanding. A classroom without interaction is a classroom without "life". Other than that, examples of mobile phone charging and electric drives for high-speed trains are used to illustrate the source of power supply and the need for energy conversion. This kind of interactive live broadcast is what makes an effective live broadcast, allowing both teachers and students to sense each other's presence and interact with each other even when they are at opposite ends of the network.

The need for online teaching at special times is not a requirement for all classes to be broadcast live [14]. The online platform is merely a tool for information transfer [15], whereas the teaching methods and approaches continue to be the core of any lesson. The constraints of space and distance make it challenging to control and direct the teaching process if knowledge is simply imparted, teachers simply instruct, and students simply listen, Teaching is about people, and the message of teaching is not only about knowledge, but also about the teacher's exploration and understanding of the issues involved as well as the teacher's emotions and teaching style. The transfer from physical classrooms to online videos involves a multifaceted adjustment of the teaching content, teaching framework, and teaching style; a commitment to a combination of teaching principles; and an attempt to adopt a variety of teaching methods in a flexible manner [2]. Teaching design resides at the heart of teaching and learning. Teaching design should be different at different times using different teaching methods. Carrying out in-depth research on teaching and learning is the prerequisite for teaching design. Only with thorough research can we understand the problem and develop a problem-oriented teaching design with a certain degree of challenge. With the advancement of information technology tools and the temptation that comes with them, teaching design is important regardless of the context. The goal of intellectual innovation has to be achieved through interactive question-and-answer sessions.

In the interactive process, teachers can use common, concrete, and interesting practical examples to stimulate students' interest in learning. For example, in power electronics, practical examples from factories, such as the beer production process and paper production monitoring system, can be used, along with materials from student competitions and circuit designs from outstanding graduation designs; in addition, research projects can also be integrated into specific examples, such as medical robots and drones. These are all areas of interest to students. Interest is what enlivens a class, and, by using interesting examples to attract the attention of students, classes will be much more effective.

There are other online resources that enable students to find solutions to difficult problems in a timely manner. During the epidemic, when students encountered difficulties, the teachers encouraged them to solve the problems on their own to help develop their problem-solving skills. The solutions can be any appropriate suggestions from forums, course knowledge obtained by asking in WeChat groups or QQ groups, or the network platforms of other schools with relevant knowledge points. The teachers then designed specific questionnaires and sent them to the students via the QQ groups. Through the questionnaires, they used the data to analyze the learning situation of students, adjust the teaching methods and contents in time, and continue exploring and reforming, so as to develop a more mature online teaching mode.

3. Curriculum construction in the aftermath of the epidemic

In the aftermath of the epidemic, university students returned to school. The means of testing prior knowledge, the methods of imparting subsequent knowledge, and the final test are all key elements of our exploration and research. These elements are closely linked to the nature and characteristics of the course and the teaching methods used during the epidemic.

After the epidemic, the power electronics course should be constructed with special periods of online teaching to achieve seamless integration of knowledge. In subsequent courses, the advantage of information-based teaching as a booster of conventional classrooms should be upheld so that students can consolidate and understand previous knowledge points while learning new ones and eventually achieve the integration of the two. The course also aims at developing students' ability to adapt to the society and improving their literacy so as to truly train talents for the society.

3.1. Theory lessons

Students are allowed to watch instructional videos from the university's platform, with some time shift, from in-class to out-of-class. The in-class sessions are used for discussion. Considering the large class size, students are divided into 20 groups and allowed to form their own QQ or WeChat groups, with around 10 students in each group. After dividing into groups, the first question is given, and the students will have to discuss it in their own groups. The discussion is then carried out depending on the students themselves, either via typing or verbally. If the discussion is carried out verbally, the volume is adjusted in such a way that it does not affect other groups of students and the teaching in other classes. When the time is up, each group will choose one representative to explain, while the others would add to it. Thereafter, the teacher and the students from other groups can direct questions to that group. Each student is given a benchmark score for this process, with appropriate marks added for accuracy and motivation. The topics discussed mainly concern analysis of basic knowledge and analysis of circuit parameters, and they can be based on investigations of basic knowledge, discussions using case studies, *etc*.

3.2. Practical sessions

For engineering students, practical sessions are constructed on the basis of theoretical classes, with the aim of enabling students to understand, consolidate, and apply theoretical knowledge through practical sessions. During the epidemic, there are too many limitations to carry out practical sessions at home, except for programming classes. After the epidemic, practical classes are arranged according to the progress of the teaching content.

Power electronics has eight practical sessions according to the Talent Development Program, which are scheduled against the progression of the basic content. There are seven experiments and one course design. Due to the epidemic, the single course design increased to three and was changed to a collaborative group effort instead of individual design. The grouping is consistent with the grouping in theoretical class discussions. The course design is taken as the final experiment, without any reduction in the number of previous experiments. Both the basic experiments and the simulation experiments lay the foundation for the course design. Basic experiments encourage students to design their own experimental schemes based on functional and performance indicators to create actual hardware circuits, while simulation experiments train students to better understand the control technology and implementation methods of conversion circuits through simulation software. Progressing from simple to complex, the course design cultivates students' teamwork spirit and ability to comprehensively apply the basic knowledge learned and establish engineering design ideas [3].

3.3. Civic education

The teaching of power electronics is objective and universal, focusing on the knowledge of power electronics [16]; the two cores, power electronic components and power electronic circuits [17]; and certain basic principles, including power electronic circuits, control methods, application methods, and other content. For decades, "ideology and politics" is not emphasized in the teaching of power electronics. Rather, the course focuses on the transmission of knowledge, the cultivation of "talents," and the use of "tools"; very little consideration has been given to the education of "people" and "morality." The teaching content, teaching design, and teaching methods for "ideology and politics" are all lacking. It is difficult to form a synergistic effect with civic science because of the preparation of teaching contents, design of teaching links, and research on teaching methods. At the same time, the target students of power electronics are those majoring in electrical engineering and automation, who generally have more technical knowledge but less social sentiment. Hence, there is an urgent need to enhance students' national sentiment and political commitment in the course.

Integrating civic education into the teaching process should be guided by the "Thought on Socialism with Chinese Characteristics for a New Era" and the goals of cultivating respect among students for scientific knowledge [18], forming a rigorous learning culture among students, establishing in students a correct outlook on life and values, strengthening students' responsibility of the times, historical mission, and dedication in learning professional knowledge, ensuring that students make due contributions to the construction of socialism with Chinese characteristics for the new era, and laying a good professional ethical quality among students for future technical work related to electrical engineering and other fields.

According to the teaching content, a mind map of knowledge points is drawn to build a seamless connection between knowledge points and the content of civics education, forming a student-centered, intellectual education-based, and moral education-supplemented professional curriculum system.

For example, after discussing all the variable current circuits of power electronics, students will be able to appreciate that power electronics, as an energy conversion technology, can be found everywhere. From the perspective of natural discernment, everything needs to be viewed in a discriminatory way [19]. As there are advantages to the development of power electronics, there must also be some disadvantages. For example, power electronics has been used by unscrupulous people to create destructive weapons, which have brought disaster to human life. In learning about technology, using it, and innovating it, students should strive to reduce the negative aspects, attempt to make favorable contributions to the progress of the society and the development of mankind, respect nature, and follow its laws. Students should be guided to think dialectically, not only in the face of technological development, but also in every aspect of their lives, be it in their studies or analyses of current events.

Power electronics is not only about students learning theoretical concepts [20], but also about their practical skills. Based on the training objectives, seven learning projects have been designed with key knowledge points as elements to reconstruct the course content, expand students' horizons for application, and enhance their practical skills. In the course of teaching, each project incorporates elements of ideology and politics into the teaching, which deepen students' understanding of professional knowledge application, and deeply explores the content of civics education embedded in professional knowledge and skills to organize teaching and improve students' professional quality, covering all aspects of literacy and actively promoting all-round development.

3.4. How grades are assessed

The conventional methods of assessing students' learning performance rely, for the most part, on the results of the final examination paper. The teaching methods used during the epidemic were in line with the nature and characteristics of the course. After the epidemic, they are based on the articulation of various contents. Students' learning process and practical skills should be part of the assessment; therefore, new and diverse assessment methods should be established. In information-based teaching, problem-oriented questioning reflects students' ability to learn independently, while discussion sessions in small groups reflect students' participation during lessons and their sense of teamwork; moreover, research methods and reports in practical modules reflect students' hands-on skills and ability to analyze and solve practical problems; random questioning in classroom through information technology tools reflects students' learning behavior. Using information technology tools to check the submission of assignments may help us determine students' learning effectiveness. In that way, we can make an objective assessment of students' learning attitude. It can be seen that these assessment methods can better reflect the overall quality of students.

In terms of the way grades are assessed, the teaching methods during the epidemic and the construction of the course after the epidemic are closely linked. A variety of teaching methods have been used to achieve the teaching objectives of power electronics, and exploratory reforms in teaching methods, teaching evaluation, and personnel training have been made. Special circumstances were encountered during the epidemic; however, there were no delays in the learning phase, especially in terms of accumulating knowledge, developing competence, upskilling, and improving engineering literacy.

4. Conclusion

The connection between online courses during the epidemic and courses after the epidemic is dependent on the characteristics of the course, the online delivery methods, the construction of online resources, the course planning after the epidemic, the way students are graded, and other factors. Exploring their organic connection is conducive to the timely adaptation of teaching methods in special periods and the complete integration of students' knowledge system.

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References

[1] Jie W, 2021, Research on computer Basic Teaching in Higher Vocational Education Under the Background of Flipped Classroom. Journal of Physics: Conference Series, 1738(1): 121–124.

[2] Liao Z, Zheng B, Xiong B, 2021, Research on the Internationalization of Computer Majored Postgraduate Education in the Background of “Double First Class” Construction. Computer Era, 2021(4): 110–112 + 116.

[3] Alexander W, Angus CD, Chandra S, 2021, Cognitive Efficiency Beats Top-Down Control as a Reliable Individual Difference Dimension Relevant to Self-Control. Cognition, 215: 818.

[4] Rahman A, Ilic V, 2018, Blended Learning in Engineering Education: Recent Developments in Curriculum, Assessment and Practice, Taylor and Francis, London.

[5] George V, 2020, Learning Online: The Student Experience, Johns Hopkins University Press, Baltimore, Maryland, 239–241.

[6] Maija NA, Markku J, 2020, Educating Self-Governing Learners and Employees: Studying, Learning and Pedagogical Practices in the Context of Vocational Education and Its Reform. Journal of Youth Studies, 23(9): 16.

[7] Dickinson P, Eade F, 2003, Whole-Class Interactive Teaching. Professional Development, 2003(1): 18–21.

[8] Wang L, 2017, Exploring the Convergence of the Mobile Learning Mode in Network Environment and the Traditional Classroom Teaching Mode. International Journal of Emerging Technologies in Learning, 12(7): 123–124.

[9] Dickinson L, Hatch D, 2015, The Experiences of a Flipped Classroom. Journal of Technologies in Education, 10(3): 10.

[10] Boondee V, Kidrakarn P, Sa-Ngiamvibool W, 2011, A Learning and Teaching Model Using Project-Based Learning (PBL) on the Web to Promote Cooperative Learning. European Journal of Social Sciences, 21(3): 498–506.

[11] Almisad B, 2019, Perceptions of the “Flipped Classroom”: A Case Study from a Developing Country. Int J of Learning Technology, 14(1): 78–98.

[12] Hinson J, Bordelon RS, 2002, Skills, Modifications, and Obstacles: Teaching Online Courses at the High School Level. Virtual Environments, 2002(1): 304–305.

[13] Hua L, 2016, To Merge Online Courses into Higher School Curriculum and Teaching System: Obstacles and Their Removal. Journal of Higher Education, 2016(5): 68–72.

[14] Villar LM, Alegre OM, 2008, Measuring Faculty Learning in Curriculum and Teaching Competence Online Courses. Interactive Learning Environments, 16(2): 169–181.

[15] Lage MJ, Platt GJ, Treglia M, 2000, Inverting the Classroom: A Gateway to Creating an Inclusive Learning Environment. The Journal of Economic Education, 31(1): 30–43.

[16] Crouch CH, Mazur E, 2001, Peer Instruction: Ten Years of Experience and Results. American Journal of Physics, 69(9): 970–977.

[17] Kassab SE, Al-Shafei AI, Salem AH, et al., 2015, Relationships Between the Quality of Blended Learning Experience, Self-Regulated Learning, and Academic Achievement of Medical Students: A Path Analysis. Advances in Medical Education and Practice, 2015: 27–34.

[18] Thorne K, 2003, Blended Learning: How to Integrate Online & Traditional Learning, Kogan Page Publishers, Great Britain and the United States.

[19] Allen IE, Seaman J, 2003, Sizing the Opportunity: The Quality and Extent of Online Education in the United States, 2002 and 2003. Sloan Consortium (NJ1), 2003(23): 659–673.

[20] Hubackova S, Semradova I, 2016, Evaluation of Blended Learning. Procedia-Social and Behavioral Sciences, 217: 551–557.