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Improved English Immersion Teaching Methods for the Course of Power Electronics for Energy Storage System in China

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ABSTRACT With the speedy progress in electrical engineering field globally, power electronics course has aroused attention from academic community. English immersion teaching methods applied to power electronics course aim to introduce advanced counterpart academic knowledge from abroad to China and equip students and teaching staffs with international views as well as English-oriented logical and critical thinking in power electronics, and thus to promote power electronics development in China in the long term. By utilizing English immersion teaching methods for power electronics course, which involves problem-based learning, English-project-based assessment method and English-based laboratory operation, the challenges that the innovative teaching methods confront could be solved during each process of power electronics course. For further illustration, English immersion teaching methods for energy storage will be analysed as a study case. Consequently, the new English immersion teaching methods for power electronics course in China can be spread and applied in other non-native English-speaking countries to upgrade and reform power electronics course and related discipline.

INDEX TERMS English immersion teaching, English-oriented logic, electrical engineering, energy storage, micro-lecture, power electronics.

I. INTRODUCTION

Power electronics course belongs to a cross edge discipline, which provides itself with a specialized elementary course in electrical engineering. Adapting power electronics course, which enjoys a pretty prominent and fundamental status, into English immersion teaching methods in China appears to be especially urgent and significant [1]. Power electronics is composed of electric power (including electrical machinery and convertor), electronic engineering (including components and circuits sensitive) and control system (including discrete and continuous course) [2], [3]. As time goes by, the three parts have been constantly refreshed and each gets new content to be supplemented, including components and parts, the variety of circuit extension system, system tech, IT tech etc. With the increasing demand for electricity internationally in terms of every aspect of modern life and industry, academic community has put more emphasis on power electronics, especially application of energy storage, and scholars have conducted more research and study on it as well. Energy storage technology belongs to the frontier science with fast pace of development and innovation. Accordingly, the teaching and application of energy storage is supposed to be updated constantly in order to better serve the development of power electronics and keep up with the energy storage technology. Meanwhile, promoting teaching of the power electronics caters for the application of the energy storage.

Traditional China's teaching mode on power electronics is rather obsolete. According to the survey, 61.43% respondents think the effectiveness of traditional teaching mode is general which means it barely makes improvement and needs to be reformed. Meantime, nearly 60% students under the traditional teaching mode in China agree to adopt English immersion teaching methods for power electronics. The courses

would impart principles of Power Devices, Power Converter Topologies, Modulation Strategies, and Drives and Protection Circuits, etc., which are mainly taught through the combination of PowerPoint and blackboard-writing. Under this teaching mode, there are barely any interactions between teaching faculties (including professors, associate professors, lecturers, and instructors, etc.) and teaching subject (students). While power electronics as an elementary course cannot achieve highly-efficient teaching results with low interactions in teaching process, for that the theories imparted in that course would be cut off from the practice and students may find it is difficult to connect the theories with practical applications. Under traditional China's teaching methods, students rely on rote memorization, which may result in failure in understanding of the internal connotation of those elementary principles and fail to apply it in practice. While under English immersion teaching mode, students have to answer the questions and instructions provided by teaching faculties. Also students are supposed to give feedback to their response and ask questions of their teaching faculties, which requires a thorough understanding of those principles, and eventually apply them in practice successfully [4], [5].

Further, other problems exist in present English immersion teaching methods for power electronics in China as well. To engage English-speaking teaching faculties or professors to teach power electronics courses is a direct way to operate this mode; however, there are a series of issues in employing or inviting professors of power electronics or related academic background from English-speaking countries. Due to different cultural background and education system, it is difficult and demanding for English-speaking professors to fully comprehend Chinese students' way of thinking and learning habit as well as their acceptance level in English immersion teaching and ability of absorbing and digesting specialized knowledge. Moreover, it is unpractical and infeasible in the long run to invite and hire English-speaking teaching faculties or professors from specific power electronics education field to Chinese universities and colleges as regular teaching faculties. Thus, to develop power electronics education in China, it is beneficial for universities and colleges to implement a reformed English immersion teaching mode to better equip students and teaching faculties with international view.

English immersion teaching methods on power electronics are brand-new teaching methods, which are totally different from the previous traditional one [6]. In the brand-new methods, Chinese students will be taught by a Chinese teacher or team of Chinese teaching faculties who speak only English to their students. In their teaching assisting facilities, experimentation, assessment and assignment, teaching faculties will utilize the English immersion teaching methods to cultivate students to form English-oriented internal logic in power electronics course.

According to the ranking list given by SJR up to 19th May 2018 (Scimago Journal & Country Rank) whose indicators can be used to assess and analyze scientific domains, there are 4 British magazines in top 12, 6 American magazines in top 12 and 1 French magazine in top 12 (shown as below).

From Table 1 given by SJR, conclusions can be drawn that China ranks lower than English-speaking countries such as the UK and the US in electric engineering academic field. And therefore, their teaching methods and teaching materials are far more advanced than China's. In order to catch up with and surpass the advanced world level, it is necessary to learn from them. With English immersion teaching mode, students can obtain authentic and unadulterated knowledge without language barrier [8].

TABLE 1. Journal rankings in electrical and electronic engineering field [7].

Country	Type	Amount
The UK	journal	4
The US	journal	6
France	journal	1
China	journal	1

According to the status quo described previously, the foreign teaching faculties and professors who are specialized in power electronics are rarely seen to take positions as regular teaching faculties in China's universities or colleges, and English immersion class for power electronics is better and more practical to be given by Chinese teaching faculties to Chinese students. Under that circumstance, it will be much easier for Chinese teaching faculties since they understand Chinese students' general learning mindset and advantage and weakness of students when preparing the teaching materials and course syllabus. Through that way, students could be better to acquire and absorb specialized knowledge of power electronics. Meanwhile, for international students, learning power electronics under the guidance of Chinese professors could equip them with specialized expertise and development situation of power electronics and related course in China [9], [10]. Aiming at cultivating students with English-oriented logic for power electronics and bringing the course in line with international practice, the power electronics will be progressed within Chinese education system in the long term.

From the angle of career development, there would certainly be a number of students choosing to become teaching faculties of their own major. While this group of students accepts English immersion teaching mode themselves, they can master the specialized knowledge of power electronics better in an international advanced level. Thus, a more advanced group of teaching faculties has been supplemented in teaching faculties and therefore, in a long run, it will benefit and improve the overall level of teaching faculties [11]. Also this teaching mode can improve the circulation of teaching faculties in this field all over the world, for that those teaching

faculties have no language barriers in teaching international students who major in electrical engineering.

Currently, the gap between China and advanced international level exists in the energy storage field, with huge potential in application and innovation for China to develop this emerging industry. For the purpose of addressing the huge demand for electricity and occupying a favorable position in international competition, it is imperative and desirable for China to strengthen the research and development for the energy storage technology and innovate the education of energy storage. Consequently, depending on the theory of power electronics, particularly power converter and control strategy, the English immersion teaching methods of energy storage has distinct significance and practical utility as a teaching example to study.

This thesis will be organized as follows: in Section 2, challenges of English immersion teaching methods for power electronics in China will be analysed from different perspectives of students, teaching faculties and teaching materials in details. The unique contribution and innovation point will be given in Section 3, while the teaching methodology in respect of challenges of English immersion for power electronics is described and shown. While, in Section 4, the comparison between traditional teaching pattern and English immersion teaching methods and the advantages of English immersion are listed and analysed. In Section 5, a case study about energy storage in power electronics would be analysed. Finally, the conclusion will be given and summarized in Section 6.

II. CHALLENGES ON THE ENGLISH IMMERSION TEACHING METHODS FOR POWER ELECTRONICS COURSE

A. CHALLENGES TO TEACHING SUBJECTS

These teaching methods require students with both high level of English language and also high level of specialized knowledge. Usually students in China have to attend the College English Test Level 4 and Level 6 (CET4/CET6). It is hard for students who cannot surpass CET4 to receive English immersion teaching mode on power electronics. According to the survey, students who valued themselves as a general English level take up 61.43%, which tells that the average English level for students in Power Electronics courses is not enough for practical application and advanced academic study. Also, students in China hardly bear the habit of reading English specialized literature or previewing background knowledge before class which directly results in lack of related specialized and language knowledge.

Students majoring in electrical engineering often undertake huge academic pressure. They share many courses such as circuits, optics remote sensing, control systems, power and energy systems, electromagnetics and so on. Adopting English-immersion teaching mode may add up to their academic pressure and lower the efficiency of their studying results. According to the questionnaire results, less than half students consider that current English immersion courses for power electronics cultivate the ability of professional English logical thinking, which is of great benefit to the learning of professional knowledge. While, more than half students hold less optimistic attitude for old English immersion method, with 37.04% students considering it is only helpful for professional knowledge learning, 11.11% students considering it has no apparent difference from traditional teaching methods, and still 3.7% students considering it lowers the studying efficiency. Thus, the current English immersion teaching methods for power electronics demand changes for improvement.

The assessment method will be diversified too in this new English immersion teaching methods. Tests and examinations will no longer be the only authorized assessment method for students' academic level. Students who study power electronics especially require the ability of cooperation learning. While in previous traditional teaching methods, students are not cultivated in cooperation learning method, which is shown in the questionnaire that among the various ways of assessment including final paper test, presentation, group assignment, final papers and experimental evaluation, only 29% students, which ranks the lowest, chose group assignment as one of their current assessment methods, comparing with 78% for final paper test and 59% for presentation and final paper. Thus, as a cooperation learning method, group assignment has not been given enough emphasis. So they may give poor performance when they first get in touch with group assignment. However, this condition is inevitable, as we can see in the logical diagram shown in Figure 1 in Section 3, and students would gradually master cooperation skills in the process.

B. CHALLENGES TO TEACHING FACULTIES

In order to simplify the analysis, the operating conditions are assumed as follows: As non-native English speakers, Chinese teaching faculties and professors are inevitably restricted to their language competence when imparting academic knowledge that is specific in power electronics course. As shown in the questionnaire results, nearly 86% teachers believe that the quality of teaching is relatively limited by their English level. Also 71.4% teachers hold that because of students' poor English proficiency, the class interaction is insufficient. Accordingly, by applying English as a teaching tool, teaching faculties may find it difficult for them to illustrate and describe power electronics principles with accurate language and detailed explanation with examples to students and make in-depth discussion with students. Under that circumstance, teaching faculties and professors would not be able to efficiently and directly deliver what they truly want to. Thus, it would produce problems for students to understand and acquire power electronics knowledge completely.

Apart from the lecture teaching for power electronics course, challenges exist in assessment as well. Although the assessment for English immersion teaching methods for power electronics course have been modified and improved to a new one with varieties of forms, in an attempt to connect with the international teaching mode, the teaching faculties

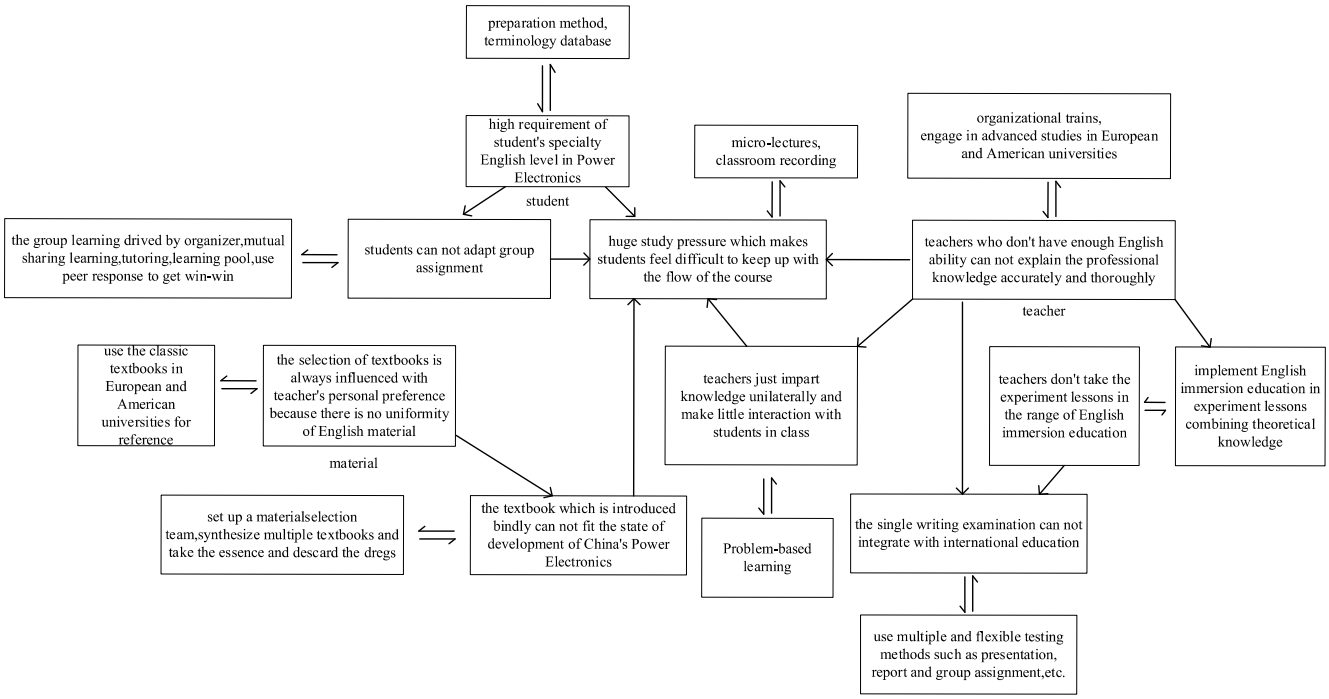

FIGURE 1. The logical diagram of the methods for the challenges in English immersion mode on power electronics in China.

tend to apply previous form of assessment, which is more emphasized on paper-based examination for power electronics evaluation. It is still limited in experience for teaching faculties and professors to find an efficient way and standard to assess students on fundamentals and principle of power electronics course out of the traditional paper-based in-class test.

Besides, according to the questionnaire results, only 25.93%, from aspect of students, of laboratory course for power electronics adopts English immersion teaching mode. And about 57% teachers agree on that the experimental class has not been included in the English immersion teaching methods. Thus, laboratory course, which is a critical and elementary component of power electronics course, has not been fully brought into the English immersion teaching methods for power electronics. As a course with theories based on practical experiment, to reform teaching methods for laboratory course with English immersion teaching methods is necessary. As we can see in the logical diagram shown in Figure 1, the relating experimentation part has been adapted in English immersion teaching methods.

C. CHALLENGES TO TEACHING MATERIALS

For the course of power electronics, no unified teaching textbooks can be traced out. Therefore, different universities and teaching faculties may have different preferences. This would easily result in curriculum logical disorder, for that different textbook may follow different internal logic. Based on a Questionnaire Investigation on University Teachers' English Immersion Course for Power Electronics, the set of textbooks for your English immersion course in your university for Power Electronics course, PPT or blackboard hand-writing made by teachers takes up the biggest proportion, while literature reading in English takes up the smallest part. This question indicates textbooks for Power Electronics are barely traditional textbooks or PowerPoint which cannot cover the current need for students. Latest literature reading in English can improve students' English level to the greatest extent and achieve the latest professional knowledge overseas.

Traditional China's teaching methods borrow and refer to the most popular textbooks in English-speaking countries such as Fundamentals of Power Electronics by Robert W. Erikson and Dragan Maksimovic, Principles of Power Electronics by John G. Kassakian, Martin F. Schlecht and George C. Verghese and so on. However, these popular textbooks may not be suitable for the status quo of China, for that Chinese students' learning level and studying ability are different from overseas ones. If textbooks are brought in without strict investigation and consideration, it would result in that the theories which students learn cannot be the guidance of their practical application. However, as we can see in the logical diagram shown in Figure 1, this challenge can be solved respectively through the promotion process.

III. THE ENGLISH IMMERSION TEACHING METHODS FOR POWER ELECTRONICS COURSE

Figure 1 describes the methods newly put forward in terms of the challenges analysed for the English immersion teaching methods for power electronics course, aiming at dealing

with the challenges and making the methods in line with the requirement of development of power electronics.

A. METHODS FOR TEACHING SUBJECTS

To better keep up with the teacher in English immersion class, students are supposed to get prepared before class and preview the teaching materials for related power electronics knowledge. An efficient way to preview English teaching materials is to build terminology database with specialized academic information introducing power electronics principles and theories. Students could update and complement the terminology database during each learning stage. Teaching faculties also would provide theses and articles as assistant in related power electronics field. Otherwise, students could improve ability of self-learning, such as looking up power electronics background and latest achievement and innovation in electrical engineering field.

In order to help students review after class and eliminate the language barrier for students in English immersion class, the record for the class will be offered in the student management system in case that they fail to follow. Furthermore, for assistant power electronics teaching, micro-lecture system is put into practice as assistance to deliver English immersion class for power electronics course [12], [13], which mainly selects important knowledge point to give quick review for the class [14], [15]. This system is formatted online and mobile learning with actual instructional content with a specific structure using power electronics English-oriented logics [16], [17]. By combining these tools, students studying power electronics will have a better learning experience in the English immersion class [18].

English language inherently has a strong logic. Adopting English immersion teaching will help students improve their logical and critical thinking while studying power electronics under English environment. This deliberate and rigorous logical thinking ability is conducive to the study of power electronics. Since students are newly experiencing English immersion teaching methods to study power electronics, they may not be familiar with logical and critical thinking for power electronics in English. Accordingly, group work is utilized to aid students with strengthen their way of logical and critical thinking. The organizer can be selected from the group and gather the whole team to discuss in English, share ideas and opinions and generate learning pool to get win-win results.

B. METHODS FOR TEACHING FACULTIES

Teaching faculties relating to power electronics often bears certain level of specialized knowledge but has not been refreshed very often and their language level cannot allow them to express and impart their specialized knowledge as they want. As shown in the questionnaire results, 61.5% teachers agree with organizing training and providing academic visit to foreign higher education institutes as methods to strengthen their English proficiency. Also 53.8% teachers accept to make academic exchanges between Chinese teachers and foreign scholars to improve English level. Therefore, regular academic visits are required for teaching faculties. World first class universities and colleges would be the first choice for them and each of them should get access to it and take turn to attend this academic visit. The most significant thing is to cultivate the internal logic of power electronics and latest teaching methods in electrical engineering field. According to the survey, 57.14% respondents tell in their school the power electronics courses are completely taught by Chinese teachers. Meanwhile, 28.32% students take that English immersion courses for power electronics should be fully given by experienced Chinese teachers with high English proficiency, and nearly 60% students and 70% teachers hold that Chinese teachers should take up the majority of the teaching faculty, with the assistance of several foreign teachers. That's exactly why academic training and visits are of vital importance.

Traditional English immersion teaching methods does not pay attention to or stress on the interaction between teaching faculties and students, which is not consistent with the core of the English immersion teaching and not conducive to train students to be English-oriented logic thinkers when dealing with power electronics issues. According to the questionnaire, 85% students and 84% teachers call for the increase of interaction during English immersion class for power electronics. Problem-Based Learning (PBL) is the method applied to settle this matter, positioning students at the centre of the English immersion teaching for power electronics course. Teaching faculties put forward questions for students to prepare before class and leave students to group collaboration and communication in form of discussion in English, emphasizing on students' reflection and reasoning to address power electronics course with practical operation [19], [20]. The role of teaching faculties is to guide, to support and to monitor the learning process while interacting with students in power electronics course. This method also aims to build students' confidence when addressing power electronics issues, and communicating with international professionals about power electronics matters, and to expand understanding and capability of practice and thinking in English-oriented logic for power electronics [21]–[23]. According to the survey, the frequency of ''occasionally'' makes up the majority (53.57%) in group session. This shows that teachers have a rather low frequency of interaction.

As shown in the questionnaire, only 7.6% teachers and 15.9% students consider that paper tests should be the only assessment method. While, the rest of the respondents hold that English immersion teaching methods should increase the proportion of experimental scores and daily tasks evaluation, as well as multi-assessment methods which value both team performance and individual performance. Diversified assessment method would be adopted, that is, English-project-based Assessment Method in the English immersion teaching methods on power electronics course. Traditional teaching methods use unitary assessment method, namely, test or examination. Using exams to decide

students' academic level is strongly opposed, especially in China. English-project-based Assessment Method will include experimentation, English presentation, class discussion outcome, literature reading outcome, group assignment, essay, homework design and comprehensive tests. Teaching faculties would not be the only adjudicators for students' grades. Peer review would also be appreciated in evaluation standards. This would make the assessment system as well as evaluation system more reasonable and scientific. English-oriented logic, solid foundation of power electronics and custom of active learning can be cultivated through this teaching method.

The experiment practice or the laboratory course weighs high importance in power electronics course teaching [24], [25]. The English-Based Lab Operation is introduced to deal with the matters including laboratory design, analysis and assessment. The principle of power electronics is supported and polished by practice and operation in laboratory. Thus, in order to enhance English immersion teaching for power electronics course, it is indispensable and beneficial for power electronics course development to apply English immersion teaching into the experimentation process [26]. For the power electronics experiment, it involves the experimental system design, parameter design, system modelling and stability analysis, device selection, PCB design, hardware circuit debugging, software programming, software and hardware debugging, experimental results measurement, experimental results analysis, further optimization of experimental design, and verification of the feasibility and effectiveness of power electronic system design, and therefore drawing useful conclusions. Due to the detail-oriented characteristic of power electronics lab practice, applying English immersion teaching in the experimentation process for power electronics course will enhance the specialized academic knowledge for power electronics for students. Adding the real operation English environment to teaching process, students will be well-informed with power electronics practice in English logics. Consequently, students will get familiar with advanced experimental methods and experimental logical thinking, helping students to discuss experimental design and experimental results with their international counterparts effectively and precisely.

C. METHODS FOR TEACHING MATERIALS

Textbook selection group is responsible for the selection and integration of textbook. As can be seen in the questionnaire results, 75% students hold that textbooks should be compiled by teaching staff, combining with students' learning situation. In order to select the textbook according to the level and status quo of the development of power electronics course, textbook selection group will choose the best suitable ones and adapt them into a new systematic book, which is under strict supervision and filter [27].

Multimedia courseware would be improved as well. PowerPoint will not be allowed to be overlapped with the content in textbooks. Video and flash would be appreciated in multimedia courseware. Blackboard writing in power electronics course needs to be completed most by students. Teaching faculties had better give hints on blackboard-handwriting so that Chinese teaching faculties in power electronics course can gradually get rid of the old-fashioned compulsory input way.

IV. THE COMPARISON BETWEEN THE COUNTERPARTS FOR POWER ELECTRONICS COURSE IN CHINA

Table 2 illustrates a comparison between traditional teaching methods on power electronics in China and English immersion teaching methods on power electronics course in China.

TABLE 2. Comparison between two counterparts.

Teaching methods	Practical level on power electronics	Overall level of power electronics	Power electronics English-oriented logic	Quality of teaching faculties	English level required by students	Textbooks	Interaction degree
Traditional	Low	Fixed	Unformed	Low	Low	Old-fashioned	Low
English Immersion	High	New and high-level	Established	High	High	Reasonable	High

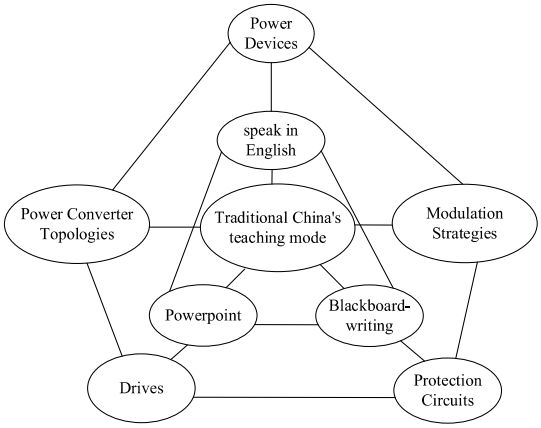

FIGURE 2. The structure of traditional China's teaching mode on power electronics course.

Traditional China's teaching mode as shown in Figure 2 on power electronics course is comparatively obsolete. The course imparts specialized power electronics knowledge including principles of Power Devices, Power Converter Topologies, Modulation Strategies, and Drives and Protection Circuits, etc., which are mainly taught in the combination form of PowerPoint demonstration and blackboard-writing. It can be seen from Figure 2 that the traditional teaching mode in China tends to be simple in form to deal with diversified knowledge components in power electronics course, suggesting the limited interaction between teaching staffs and students.

English immersion teaching mode as shown in Figure 3 on power electronics course is a newly-proposed teaching method, which is different from the traditional one with advancement and adjustment in terms of power electronics

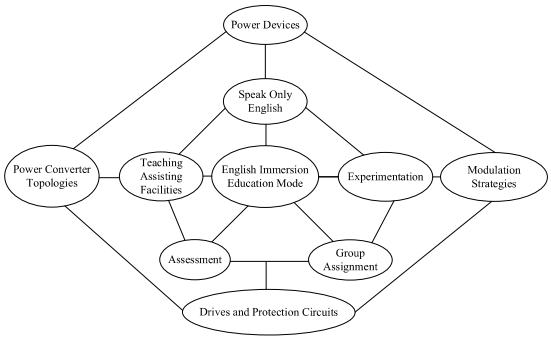

FIGURE 3. The structure of English immersion teaching mode on power electronics course.

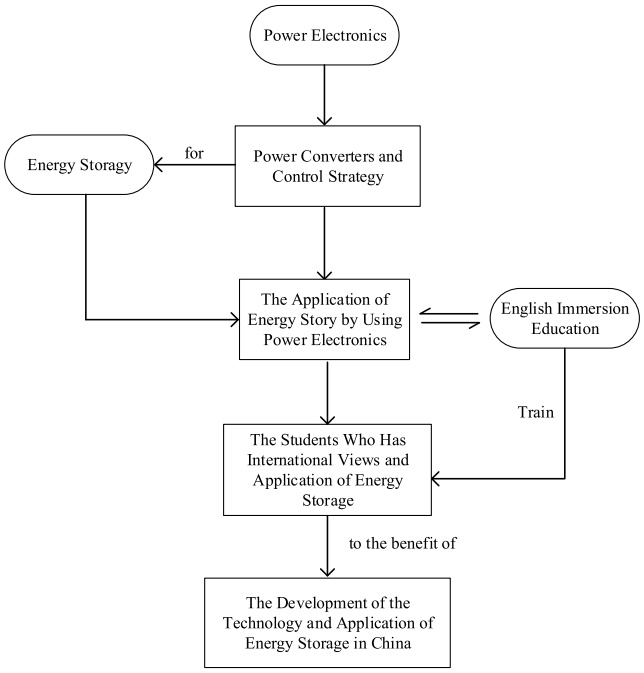

FIGURE 4. The effect of English immersion teaching on the course of power electronics for energy storage.

course issues in China. English is the only communicative tool that delivers specialized knowledge and reflects opinions for both teaching faculties and students. Diversified forms and methods are proposed for theory and practise class for improvement, which are containing teaching assisting facilities, experimentation, assessment and group assignment. From Figure 3, it can be drawn that the methods are helping to stress on the critical thinking and English-oriented logical thinking for power electronics course. Moreover, the interaction between teaching faculties and students is comparatively increasing in form in power electronics course, which further promotes involvement and ability of English-oriented specialized logical thinking for students studying power electronics.

According to the questionnaire results, 85% teachers hold that comparing with traditional teaching mode, the English immersion teaching methods for power electronics have a variety of advantages, involving connecting with the English thinking logic and the international level of Power Electronics, which has higher practical significance and promoting teachers and students to improve their professional English level and ability to better relate to the development of international Power Electronics. Meanwhile, 55% teachers believe that the use of advanced foreign textbooks is more conducive to learning advanced Power Electronics technology and learning from foreign class content, and English teaching strengthens the interaction between teachers and students. The practical level on English power electronics course is low under traditional methods, and it will be comparatively high in English immersion methods for English immersion pays more attention to the connection between theories and practical application. The overall level of English power electronics course in China is fixed under traditional methods and it will be new and of high level under English immersion methods for English immersion methods can provide itself with constantly refreshed and advanced information and knowledge from the whole world. Power electronics English-oriented logic has not been formed under traditional methods, and it will be established under English immersion methods, for English immersion methods can pay more attention to the internal logic to power electronics between theories and practical application. The quality of teaching faculties is low under traditional methods, and it will be comparatively high under English immersion methods for that teaching faculties can participate in regular academic visit to improve and renew themselves. English level required by students is low under traditional methods, and it will be comparatively high under English immersion methods, for that students under traditional methods are compulsorily input English specialized knowledge without utilization and interaction while English immersion methods can help students think independently and actively in English power electronics logic. The textbooks are old-fashioned under traditional methods, and it will be reasonable and scientific under English immersion methods for a specified textbook selection group will be set up to help sort out a suitable textbook for students. Interaction degree in class is low under traditional methods, and it will be high under English immersion methods for PBL teaching method will be adopted to improve the class interaction degree.

All in all, English immersion teaching methods are superior to the China's traditional teaching methods from every considerable aspect as we can observe from the comparison in Table 2.

Therefore, traditional teaching methods render students in power electronics course with a passive study mode and thus rigidify the specialized knowledge and will lag behind advanced world level. English immersion teaching methods let students master the skills and aspiration of active learning and thinking on power electronics course and therefore make a solid foundation for other courses and disciplines in electrical engineering which can steadily enhance the overall level of electrical engineering.

V. APPLICATION OF THE ENGLISH IMMERSION TEACHING METHODS FOR POWER ELECTRONICS:TAKING ENERGY STORAGE SYSTEM AS AN EXAMPLE

Based on the previous discussion and analysis, English immersion teaching methods for power electronics course could apply to the teaching and application of energy storage, with pragmatic significance for the students, teaching faculties and the development of the whole discipline. Relying on power electronics, power converters and control strategy, the application of energy storage via English immersion teaching methods would train students with international views and English-oriented logic for the research on energy storage, as well as develop the technology and application of energy storage in China.

Based on the previous discussion and analysis, English immersion teaching methods for power electronics course could apply to the teaching and application of energy storage, with pragmatic significance for the students, teaching faculties and the development of the whole discipline.

The case study would start from the selection of teaching faculties. All native English-speaking teaching faculties are infeasible for the departments of electrical engineering in China's universities. Therefore, teaching faculties with both solid expertise of power electronics for energy storage and solid foundation of English language would be selected and form a professional team of teaching faculties. And then, regular academic visit about energy storage research would be organized to world-renowned institutions of higher learning such as Massachusetts Institute of Technology, University of the Incarnate Word, Imperial College London, ETH Zurich and etc. All members of teaching faculties must share this academic visit in turn and attain academic proficiency test annually. Then textbook on energy storage should be developed by teaching faculties according to academic papers such as Power Electronic Interface for Energy Management in Battery Ultra-capacitor Hybrid Energy Storage System [28], Enhancing Engineering Education via Physical Experiments: The Case of Learning Energy Storage with a Flywheel System [29]and etc., because energy storage is an emerging technique and systematic textbooks have not been formed yet.

PBL method, stressing on the problem-solving learning and teaching, is applied before the class to guide students to do preview studies. Teaching faculties raise key questions about energy storage, such as efficiency issues, for students to do research and critical thinking as preparation. Meanwhile, academic database and literature readings including articles, journals and papers about latest and cutting-edge technology and application for energy storage efficiency are provided for students as further preparation, such as Power electronics converters without DC energy storage in the future electrical power network [30], Process configuration of Liquid-nitrogen Energy Storage System (LESS) for maximum turnaround efficiency [31], Energy efficiency and capacity retention of Ni–MH batteries for storage applications [32]. Students could read energy storage literature materials based on the academic database for specialized English terms of energy storage efficiency first. Afterwards, students summarize and update new academic terms and definitions to English database on energy storage efficiency issues according to the literature readings, for instance, bulk power system, pulse width modulation converter, matrix converter, Liquid-nitrogen Energy Storage System (LESS), Aspen Hysys, capacity retention, battery durability.

During in-class process, teachers would arrange blackboard-handwriting in an English-oriented power electronics way. The content of handwriting would contain the logical outline of the whole class. Students will rely on the outcome of literature reading to fill in the blank of logical outline that teachers have provided. Multimedia video and PowerPoint will be provided to supplement students' background knowledge on energy storage topic. Then, teachers will utilize PBL method to intensify the interaction between two parties. Teachers will first put forward a question, for instance, how to improve the efficiency of energy storage. Students will give answers according to their reserve of knowledge and also the outcome of their literature reading provided by teachers before class. Next, teachers will further put forward questions which are more detail-oriented and more specific, for instance, about electro-mobile optical storage charging plant, new energy generation. Then group discussion will be arranged to solve these problems and each group will give a short presentation to display their answers and outcomes. Key and difficult points will be explained and imparted in teachers' later lecture to interpret and emphasize the teaching content.

After discussion and presentation about energy storage efficiency, teaching faculties would give feedbacks and comments on the students' performance and questions as well as answering students' questions. Since the specific topic groups discussed on efficiency of energy storage is diversified, teaching faculties would leave time for them to exchange ideas and opinions. Suggestions would also be given to students on how to improve the efficiency of energy storage in order to generate the benefit and practicability for the application of energy storage. At the end of the class, new questions for next topic of the energy storage will be presented to students as continuous study. Generally, recording of in-class energy storage teaching content, involving teaching faculties' lecture, comment and answers to the students' questions will be put online on the student administration system for review.

As for the laboratory operation class of energy storage section, English immersion teaching methods for the contents of energy storage will contain experimental design, operation, and results display. Initially, teaching faculties will explain the design of the experiment to students in English. For example, an experiment for energy storage system includes the following steps: calculation of voltage and current parameters of battery, the parameter analysis of inductance and capacitance, power device selection, establishment and stability analysis of mathematical model of energy storage system, bidirectional direct current of the energy storage system, joint debugging of converter hardware and software, energy

management in charging and discharging processes of energy storage system.

For the purpose of reviewing after class, micro-lecture as a tool will be provided by teaching faculties for students to find answers and build an overall structure and knowledge system of the contents of energy storage. Application of energy storage is based on the principle of the power electronics, with English-oriented logic for power electronics.

Assessment method would include many parts as we already discussed previously. The first part would be overall and separate presentation. Students' grades would be given according to each presentation in their class and would account for 10%. The evaluation standard would be set according to if their outcome of energy storage could be to some extent applied into practice. The second part is group assignment, which can be classified as project report and group essay. Project report will consider both students' individual participation and cooperating results. Group essay will consider to what extent students' outcomes can guide their experiment in energy storage. In this part, teachers would not be the only adjudicators for students' grades. Peer review from classmates would be taken into consideration too. The second part would account for 15%. The third part is personal essay, which would account for 15%. Students would accomplish a personal essay, for instance on the relative contents of energy storage, within the scope of their class content, after-class findings, experimental classes and so on. The fourth part, accounting for 35%, would be the mid-term and final examination, which are using paper exam to evaluate students on theoretical level of energy storage technology. The fifth part is attendance and performance, occupying 10% of the assessment, which reflects the students' involvement during the class. Finally, taking up 15%, the sixth part would be assessment for laboratory operation, which would examine students' actual understanding of energy storage technology. In a word, different parts in assessment together would present a comprehensive result about students' academic level for the energy storage technology.

VI. CONCLUSION

This paper proposed a new English immersion teaching mode (including PBL method, English-project-based Assessment Method, and English-based Laboratory Operation) for power electronics course, particularly for energy storage in China. Despite it exploratory character, it endows students in power electronics course with English-oriented power electronics logic and gets rid of the barrier, which was given by traditional teaching methods on power electronics both in language and thinking. Also, the teaching methods can equip students and teaching faculties with international view and update academic information in related areas, which will further promote academic innovation and carry out reform within the discipline. Lastly, English immersion teaching methods in China could provide other non-native English speaking nations as an example with experience and practice in power electronics discipline. Through learning from the English immersion teaching methods in China, other countries could implement their own teaching reform and adjustment within power electronics course and spread to other levels of disciplines. Meanwhile, this mode could absorb more international students, promote academic innovation and exchange academic thoughts and latest progress in power electronics or even whole electrical engineering field.

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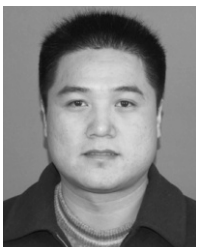

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