Optimization of a Hybrid Learning Approach for Power Electronics Course Using Virtual Laboratory

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Abstract Many challenges need to be addressed in facing the Industry 4.0 (I4.0), especially for teachers in schools or colleges. One of them is how to adapt a learning process with I4.0 where computers and technologies play an important role. A hybrid learning approach using a virtual laboratory could be the answer to this problem. Hybrid learning combines face-to-face learning, e-learning, virtual laboratory and practice in a laboratory. It could optimize the advantages of all methods and introduce educational technology to students. Furthermore, it will prepare the vocational teacher candidates in facing the I4.0. This paper focuses on developing, implementing and optimizing a power electronic course for vocational students with a hybrid learning approach using a virtual laboratory in Universitas Negeri Yogyakarta, Indonesia and it is based on the author's experiences. The hybrid learning approach is validated by experts from electrical engineering education using an assessment method and analyzed by means statistically. The result shows that the hybrid learning approach by using virtual laboratory can be adopted for improving the analytical thinking in solving power electronics problems for students as a vocational teacher candidate.

Keywords hybrid learning approach, power electronics, e-learning, vocational teacher, industry 4.0

1 Introduction

Modern industry in the era of industrial revolution 4.0 (I4.0) has led to an increase in energy requirements, especially from renewable energy. Most of the energy that is used by a human being is electricity. To improve the quality and efficiency of electrical energy, many things can be done by converting energy. However, traditional converter systems are insufficient to increase the controllability, capacity, and the efficiency of power as well as efficiency for energy systems [1]. For these reasons, current studies are now more focused on electronics switching. Power electronics consist of electronic switching principles to convert from Alternating Current (AC) to Direct Current (DC), DC to DC, AC to AC and DC to AC [2]. It is used in a wide range of applications such as motor controls, industrial applications, vehicle systems, electromechanical controls, and power systems integration of renewable energy resources [1, 2]. It becomes a subject course in the electrical engineering education curriculum for preparing teachers in electrical engineering fields.

The most common teaching approach used in higher education is a face-to-face lecture, and it is known as the traditional teaching. However, in recent years, the lecture is described as passive teaching, because it discourages students to think critically and construct their learning. It focuses only on face-to-face interaction. It does not accommodate student opportunities for collaborative learning. Moreover, it does not give a chance to the instructors to implement learning with analytical and critical thinking skills [3, 4]. As a result, students may feel bored in a classroom with traditional teaching [5]. They usually do not get motivated by the face-to-face classroom. Besides, they might think it will not bring any benefit for their future careers. Therefore, they pay less attention to the lectures. They do not care and do not participate in the class. As a result, it can cause behavioral problems for them.

Nowadays, the learning and teaching process on power electronics course have changed greatly. Science and technology have become digital and an integral part of the educational system in many countries. Many institutional educations provide e-learning to support the learning process such as downloading lecture notes, learning web-based materials, attending web-based lectures and video lectures [6]. Many lecturers have investigated the scope of information and communication technologies in education [3, 4, 7]. On the other side, some lecturers have developed the virtual laboratory to give the practical skill for students and implemented in many subject areas such as Chemistry [5], Electronic Engineering [8], Robotics [9], Science [10] and Power Electronic [11, 12]. The implementation of online learning and virtual laboratories has many advantages. They are easy to use, reduce time, and allow students to perform several experiments within a limited time and plan their future studies carefully [3, 5, 7, 10].

However, there are some problems with the way of teaching with e-learning or virtual laboratories, especially for the engineering subject like a power electronics course. E-learning or virtual laboratories cannot satisfy the needs of the participants in the educational process. Skill development must be obtained by experiment rather than only computer simulation through e-learning or by the virtual laboratory. As a teacher candidate in vocational school, students must have analytical and critical thinking skills to collect and analyze information, solve problems and make the best decision [13]. It can be improved by some learning methods such as causal thinking, creative thinking, knowledge-seeking, systematic problem solving, and decision-making. The analytical and critical thinking skills can be measured from several aspects like 1) inquisitiveness, 2) self-confidence, 3) analyticity and 5) maturity [13, 14].

2 The Objective of The Study

Considering the previously defined statement, the main objective of this study is:

a. Developing a hybrid learning approach using a virtual laboratory to increase analytical and critical thinking skills on solving the problems in the power electronics course.

b. Implementing the power electronics course using a hybrid learning approach to increase analytical and critical thinking skills on solving the problems in the power electronics course.

c. Optimizing the power electronics course using a hybrid learning approach with the combination of face-to-face, e-learning, virtual

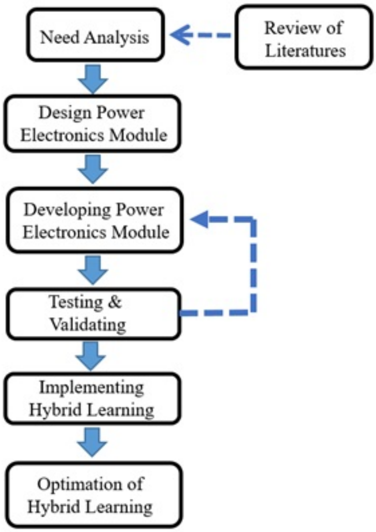

Figure 10.1: The procedure of research

laboratory and practice in the real laboratory to increase the analytical and critical thinking skills on solving the problems in the power electronics course.

3 Research Method

The research of the optimization of a hybrid learning approach using virtual laboratories in power electronics courses is carried out through a procedure as shown in Figure 10.1. The first step involves the research and information collecting for the need analysis. It is conducted by literature reviews, classroom observations, and report preparation for the state of the art. The second step is to design a Power Electronics module. The next step is developing the Power Electronics module that consists of a manual, e-learning, a virtual laboratory, and a laboratory module.

The fourth step is the validation of the power electronics module by the electrical engineering education expert. The fifth step is implementing a hybrid learning approach in the power electronics course with

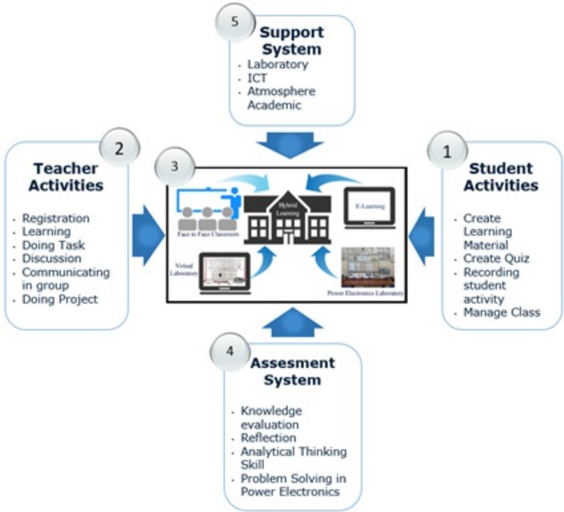

Figure 10.2: The hybrid learning approach using virtual laboratory

integration of a virtual laboratory. The implementation of the hybrid learning approach has carried out through classroom action research. The instrument that used to measure the module of hybrid learning on power electronics course was a questionnaire using a 4-point Likert scale ranging from 1 (very weak) to 4 (very good/strength). The competence of students will be measured by a test and the analytical and critical thinking skills were measured by observation of the students about inquisitiveness, self-confidence, analyticity, and maturity.

4 Result and Discussion

4.1 Developing Hybrid Learning Approach

The hybrid learning approach using the virtual laboratory on power electronics course is illustrated in Figure 10.2. The components of hybrid learning using a virtual laboratory on power electronics course are composed of fives elements. There are 1) student activities, 2) teacher activities, 3) hybrid learning, 4) assessment system, and 5) support system. The development of a hybrid learning module was based on the need of analysis.

The hybrid learning module was validated by three experts from electrical engineering education who have experience in e-learning, computer media development, and virtual laboratory. Based on the judgment from the experts, the hybrid learning approach applied in the power electronics course with virtual laboratory is highly recommended with an average score of 3.22.

Average scores of 3.22 can be interpreted as good level; it means all experts give a good or a very good interpretation in each aspect of the hybrid learning module on the power electronics course. They agree and give a good rate to the hybrid learning approach module with confidence. Meaning, it can be implemented to improve analytical thinking skills and evaluation ability for problem solving in the power electronics fields.

Table 10.1: The expert judgment to the hybrid learning approach on power electronics course

No	Aspects of Hybrid Learning Approach	Mean	Interpretation
1	Usefulness of Power Electronics module in hybrid learning	3,10	Good
2	Face to face activities	3,02	Good
3	E-Learning activities	3,42	Very Good
4	Virtual laboratory	3,36	Very Good
5	Laboratory activities	3,04	Good
6	Assesment system	3,38	Very Good
	Summary	3,22	Good

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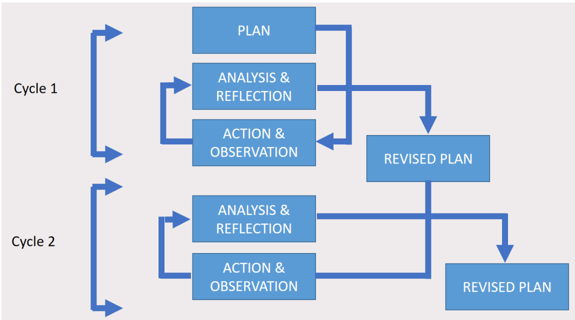

Figure 10.3: Class Action Research in Power Electronics

4.2 Implementation and Optimization

The implementation of hybrid learning, using a virtual laboratory on the power electronics course, is done in the odd semester from September until December 2018. It is implemented by class action research to obtain the best method for implementing a hybrid learning approach in the power electronics course. Active learning strategies are used to allow students to participate in the classroom, e-learning, virtual laboratory and practice in the laboratory. This method can enhance the skill such as analytical skill, communication skill, and social skills.

Table 10.2: The average score test and analytical thinking skill

No	Aspects	Cycle 1	Interpretation	Cycle 2	Interpretation
1	Test Score	6,22	Enough	7,96	Good
2	Inquisitiveness	2,42	Weak	2,92	Good
3	Self-Confidence	2,68	Good	3,28	Very Good
4	Analyticity	2,62	Good	3,32	Very Good
5	Systematicity	2,48	Weak	3,12	Good

Table 10.2 shows the result of test score and analytical thinking skills aspect through the implementation of the hybrid learning approach in cycle 1 and cycle 2. The learning process in cycle 1 was done by a hybrid learning approach without the virtual laboratory. Cycle 2 was done by

a hybrid learning approach using the virtual laboratory.

The combination of face-to-face, e-learning, virtual laboratory and practice in the laboratory was planned, done, analyzed and reflected in each cycle. Based on 2 cycles of hybrid learning using virtual laboratory, we identified the following strategies to achieve the best results:

a) Theory in classroom: Power electronics learning starts from learning activity in the classroom with the face-to-face method organized by the teacher. Face-to-face learning in the classroom is meant to provide basic provisions for electronic concept theory. From this learning, students are expected to have knowledge as a solution to solve some problems in power electronics fields. The active learning method is implemented in the classroom with the face-to-face learning process.

b) Simulation using virtual laboratory: The virtual laboratory is a laboratory clone obtained through the use of computers and software. The use of a virtual laboratory is aimed so that students could understand the procedures and do experiments in the real laboratory. Virtual learning is done by using power electronics computer-based learning media, Power Simulator (PSIM) and Personal Simulation Program with Integrated Circuit Emphasis (PSPICE) software to help students understand the procedures of designing and analyzing the power electronic circuits.

c) Practice in real laboratory: Laboratory activities begin with the introduction of tools and materials, measurements, and testing devices, identifying tools and practice materials, assembling power electronic circuits (rectifiers, controlled rectifiers, AC regulators, DC chopper and inverters), measurement process and analyzing input and output of the circuit. Student activities in the laboratory are designed by the project-based learning which has a chance for the lecturer to give some assignments to the students, for example, designing power electronic circuits and solving real-world problems.

d) Analysis: The next step is to analyze the results of laboratory activities in accordance with the theory that has been given. The analysis is carried out in the form of reports accompanied by data on the results of lab works and projects. Every student must make a laboratory activity report for every given job.

e) Presentation: The final step in hybrid learning is to present the results of the project that students are working on. Presentations are conducted in groups. It aims to train the students to work in a group.

5 Conclusions

The hybrid learning approach on the power electronics course integrated a variety of learning methods. Traditional face-to-face learning in the classroom gives some basics knowledge for students. E-learning adds the student's understanding of theory and self-paced learning. It contributes to the improvement of analytical thinking skill, and to the evaluation of ability to solve problems in power electronics fields. A presentation can give the students experience to prepare, design, practice and present the theoretical concepts in class.

The optimization of the hybrid learning approach for the power electronics course was done by integrating all of the resources related to conventional teaching, e-learning, virtual laboratory and practice in the laboratory. Students are more interested and they keep their attentions in class, e-learning, virtual laboratory and practice in the laboratory. Altogether, this research shows that hybrid learning can be adopted for improving analytical thinking skill in solving power electronics problems for students as a vocational teacher candidate.

References

1. M. H. Rashid, *Power Electronics: Devices, Circuits, and Applications*. New Jersey: Prentice-Hall, 2003.
2. M. Ali, *Aplikasi Elektronika Daya pada Sistem Tenaga Listrik*. Yogyakarta: Universitas Negeri Yogyakarta (UNY) Press, 2018.
3. A. V. Balastov and E. Y. Sokolova, "Adult Learners ' Communicative Foreign Language Competence Development in Higher School Via Information Technology and Multimedia Implementation," *Mediterranean Journal of Social Sciences*, vol. 6, no. 1, pp. 537–543, 2015.

4. A. Buran, "How to Use Blogs in Creating Special Opportunities for Language Learning," *Mediterranean Journal of Social Sciences*, vol. 6, no. 1, pp. 532–536, 2015.
5. C. Tüysüz, "The Effect of the Virtual Laboratory on Students ' Achievement and Attitude in Chemistry," *International Online Journal of Educational Sciences*, vol. 2, no. 1, pp. 37–53, 2010.
6. M. Ali, "Peningkatan Kualitas Pendidikan dan Pembelajaran Melalui Teknologi Informasi dan Komunikasi di Universitas Negeri Yogyakarta." Prosiding SENTIA Politeknik Negeri Malang, 2009, pp. C1–C5.
7. D. L. Matukhin and A. M. Evseeva, "Further Professional Training as a Constituent Part of Continuing Vocational Education," in *Lecture Notes in Management Science*, 2014, vol. 31, pp. 104–109.
8. M. Macias, V. Cazares, and E. Ramos, "A Virtual Laboratory For Introductory Electrical Engineering Courses To Increase The Student Performance." 31st ASEE/IEEE Frontiers in Education Conference, 2001.
9. F. A. Candelas, S. T. Puente, F. Torres, F. G. Ortiz, P. Gil, and J. Pomeras, "A Virtual Laboratory for TeachingRobotics," *Int. J. Engng Ed.*, no. 3, pp. 363–370, 2003.
10. D. Liu, P. Valdiviezo-Diaz, G. Riofrio, Y.-M. Sun, and R. Barba, *Procedia Computer Science*, vol. 75.
11. R. Coteli and A. O. Gokcan, "Virtual Laboratory for Power Electronic Based Reactive Power Compensators," *Tehnički vjesnik*, vol. 25, no. 1, pp. 86–93, 2018.
12. K. Cheng, C. Chan, N. Cheung, and D. Sutanto, "Virtual Laboratory Development for Teaching Power Electronics," in *IEEE 33rd Annual Power Electronics Specialists Conference*, 2002, pp. 461–466.
13. A. Doyle, "Creative Thinking Definition, Skills, and Examples," https://www.thebalancecareers.com/creative-thinking-definition-with-examples-2063744, online (Accessed: 2019-04-05).
14. P. A. Facione and N. C. Facione, "The Holistic Critical Thinking Scoring Rubric: A Tool for Developing and Evaluating Critical Thinking," http://www.affect-reason-utility.com/1301/Rubric.pdf, 1994, online (Accessed: 2019-01-21).

Proceedings of the 1st Interdisciplinary PhD Workshop of Media Computer Science 2019

Bibliografische Information der Deutschen Nationalbibliothek
Die Deutsche Nationalbibliothek verzeichnet diese Publikation in der Deutschen National

Bibliographic information published by the Deutsche Nationalbibliothek
The Deutsche Nationalbibliothek lists this publication in the Deutsche Nationalbibliografie; detailed bibliographic data are available in the Internet at http://dnb.d-nb.de.

ISBN 978-3-95908-196-2

THELEM Universitätsverlag
GmbH und Co. KG
http://www.tudpress.de

Gesetzt von den Herausgebern.
Printed in Germany.

TUD*press*
2020

Vorwort

Im Zeitraum vom 5. bis 7. Januar 2019 fand im Internationalen Informatik- und Begegnungszentrum Sachsen IBS in Laubusch der „1st Interdisciplinary PhD Workshop of Media Computer Science 2019“ statt. Das übergeordnete Ziel des Workshops bestand darin, die Fallstricke einer institutionellen Forschung in der Startphase der Promotion zu überwinden und dabei die angehenden PromovendInnen zu befähigen, ihre wissenschaftlichen Beiträge innerhalb einer wohlwollenden, aber kritisch eingestellten Community einzuordnen.

Thematisch angesiedelt war der Doktorandenworkshop an der Schnittstelle verschiedener Disziplinen und Fachbereiche aus der Informatik und den Sozialwissenschaften. Er förderte durch kooperatives Engagement von neun Professoren und Betreuern aus drei sächsischen Hochschulen (HS Mittweida, TU Chemnitz und TU Dresden) in einem innovativen 3-tägigen Format das wissenschaftliche Arbeiten und die Entwicklung von Soft Skills der 18 PromovendInnen in besonderem Maße. Hierbei wurden klassische Elemente und Methoden eingesetzt, die von der gegenseitigen Vorstellung der individuellen Arbeitsthemen bis zu wissenschaftlichen Arbeitsanleitungen reichten. Darüber hinaus sollten die Promovenden mit Unterstützung erfahrener Wissenschaftler und Projektleiter innerhalb eines innovativen Formats wissenschaftliche Domänen in Kurzform gruppenbasiert ergründen und gewonnene Erkenntnisse präsentieren. Ein Open Review der eingereichten Promotionsbeiträge komplementierte die zuvor aufgeführten Formate.

Der Promovendenkreis entstammte den nachfolgenden Nachwuchsforschergruppen:

Agile Publika: Die vom European Social Fund (ESF) geförderte Nachwuchsforschergruppe, bestehend aus fünf Doktoranden und einem Postdoc, erforscht Themenstellungen, welche für die lokale Öffentlichkeit von besonderer Relevanz erscheinen. Dabei stehen Bewegungsmuster und Nahverkehr ebenso im Fokus wie beispielsweise Meinungsbildungsprozesse in sozialen Medien.

Methodisch liegt der Schwerpunkt bei der Untersuchung dieser Phänomene mittels computergestützter maschineller Analysen. Die Gruppe ist interdisziplinär und hochschulübergreifend zwischen den Fakultäten Medien und Angewandte Computer- und Biowissenschaften der Hochschule Mittweida und dem Medienzentrum der TU Dresden am Schnittpunkt von Informatik und Kommunikationswissenschaft aufgestellt.

localizeIT: Im Rahmen der Innovationsinitiative Neue Länder "Unternehmen Region" förderte das BMBF seit dem Jahr 2005 unterschiedliche Projekte, wozu das Projekt sachsmedia (2007 bis 2012) sowie die Stiftungsjuniorprofessur Media Computing mit ihren 5 Mitarbeitern im Projekt "localizeIT – Lokalisierung visueller Medien" an der Fakultät Informatik der TU Chemnitz (2014 bis 2019) zählen. Eine wesentliche Zielsetzung besteht darin, durch automatische Analyse von Ton-, Bild- und Videomaterialien zu einem semantischen Verständnis der Medien der lokalen Fernsehlandschaft zu gelangen, wobei insbesondere die Klassifikation und Verortung der darin enthaltenen Personen und Objekte eine große Rolle spielen.

Der Tagungsband präsentiert die im Ergebnis des Workshops überarbeiteten Beiträge, welche aus dem interdisziplinären Austausch von Wissenschaftlern und Nachwuchsforschern der TU Chemnitz, der Hochschule Mittweida und der TU Dresden hervorgegangen sind und sich in die Schwerpunkte Maschinelles Lernen und Life Sciences, Multimodale Datenanalyse und Big Data, Social Analytics und E-Learning einteilen lassen.

Viel Freude beim Lesen wünschen Ihnen
Ihre Herausgeber und Workshop-Organisatoren

Jun.-Prof. Dr. Danny Kowerko (TU Chemnitz, Jun.-Prof. Medieninformatik)
Prof. Dr. Marc Ritter (HSMW, Professur Medieninformatik)
Prof. Dr. Thomas Köhler (TU Dresden, Medienzentrum)
Dr. Kristina Helle (HSMW, Modellbildung und Simulation)

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