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Abstract— In this review, we describe various kinds of problem and solution related teaching and learning on power electronics course all around the world. The method was used the study of literature on journal articles and proceedings published by reputable international organizations. Thirty-nine papers were obtained using Boolean operators, according to the specified criteria. The results of the problems generally established that student learning motivation was low, teaching approaches that are still teacher-centered, the scope of the curriculum extends, and the physical limitations of laboratory equipment. The solutions offered are very diverse ranging from models, strategies, methods and learning techniques supported by information and communication technology.

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A Review of the Teaching and Learning on Power Electronics Course

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***Abstract*—In this review, we describe various kinds of problem and solution related teaching and learning on power electronics course all around the world. The method was used the study of literature on journal articles and proceedings published by reputable international organizations. Thirty-nine papers were obtained using Boolean operators, according to the specified criteria. The results of the problems generally established that student learning motivation was low, teaching approaches that are still teacher-centered, the scope of the curriculum extends, and the physical limitations of laboratory equipment. The solutions offered are very diverse ranging from models, strategies, methods and learning techniques supported by information and communication technology.**

Keywords—power electronics course, literature review, teaching and learning

I. INTRODUCTION

The power electronics course is a compulsory subject in majors or course in technical and vocational education and training, both educational and non-educational disciplines in Indonesian. The course is a branch of electrical science that studies the field of electronics applications related to energy or electric power. The course is a multidisciplinary sciences area inside the electrical and electronics engineering domain.

The generally, this course discusses electronics systems, circuit theory, systems and control theory, signal processing, electromagnetic, computer and simulation studied, electrical machinery, power systems and solid-state physics. It can be stated that the field of study includes abstract concepts, there are many electronic components, analysis of relationships between electronic circuits, involving calculations of mathematics, there is also computer programming, waveform analysis, the content of complex and deep learning materials, the existence of the design, curriculum extended, including the course in practice and also involving communication technology.

The concepts contained in this course is quite difficult for the educators to prepare the course content in an integrated manner at the students' level. The teaching materials contained there in are widely used as supplies to enter the business and industrial world. Growing rapidly the development of electrical and electronics technology has become a challenges in teaching and learning in this course.

This work is structured as follows: section I is introduction, section II is the related work, section III is the method, section IV results and discussion, section V is the conclusion.

II. BACKGROUND

Teaching is a rather difficult concept to understand and quite difficult to define [1]. Scientists and researchers from different disciplines have used different teaching definitions [2]. Teaching is activity that was tightly bound, systematic and has principles in order to achieve effectiveness and efficiency in achievement [3]. Learning is the process by which knowledge were created through the transformation of experiences [4]. Learning could be defined as the effect of experience on behavior [5]. Teaching and learning are effort made by teacher and student be able to obtain the goals and achievements of learning in accordance with what was expected. Learning that can really change the condition of the students from the unknowing becomes knowing, from who already know to be deeper knowledge, from the less good attitude or behavior to be good, from which have good attitude and behavior become better, which is not skilled at being skilled and who have become skillful becoming more and more skilled.

The models of teaching included strategies, methods and learning techniques. It's instructional approach to exploring the effects of the presences on complex practice [6]. The models of teaching also involves the management of time allocation on face-to-face meeting for one or more content material [7], teachers, architects, interior designers, IT managers, educational leaders and students [8].

Learning strategies are activities undertaken by teachers college and students college in order to achievement the goals that have been determined. The design of instructional strategies is prepared in a lecture plan that was usually for onesemester. Learning strategies includes methods and techniques or tactics applied by teacher and student on the situation and certain conditions in the class face to face directly or outside the class is not face to face directly [9]. Learning strategies are activities undertaken by teacher to help student to build or connect between what they already know and what to learn next. By using elaboration strategies, they can integrate new and old understanding in meaningful ways to produce a higher understanding [10].

The methods of teaching was to create activities can provide learning opportunities to further develop the cognitive, social, affective and hard skills required of student within the context of professional practice [11]. The methods of teaching was often interpreted as the same as teaching techniques. There is no standart method of teaching in many cases and situation. The methods described in the literature include tutorials, lectures, teaching rounds and self-directed learning [12].

III. METHOD

To find articles for this paper, the web of science was used to search for teaching and learning on the power electronics course of reading material in the review. Sourcing articles from the site:

- http://ieeexplore.ieee.org/Xplore/home.jsp
- http://www.sciencedirect.com/science/journals
- https://onlinelibrary.wiley.com/
- http://www.hindawi.com/journals
- http://www.springer.com/gp/
- http://www.wiete.com.au/journals/GJEE/Publish/index.html
- http://penerbit.uthm.edu.my/ojs/index.php/JTE

The provision of site selection criteria that is setting must from associations and or institution of publisher of accredited, reputable and internationally accredited journal or indexed such as SCOPUS. All databased were searched with the same keyword: teaching, learning, power electronics, model, method, strategy and education. Additional or alternative keywords: learning power electronics, science learning, learning science, science teaching, teaching science, science instruction and science education on power electronics course. Then do a search on each database of web page site (site visit) is using the same main keywords: teaching power electronics and learning power electronics.

A set of keywords was used in combination with the Boolean operator "And" and "Or". After duplicates were removed, 178 articles were left for further selection on database IEEE xplore, 91 articles on database ScienceDirect, 74 articles on database Wiley, 1 article on database Hindawi, 1 article on Springer, 1 article on Wiete and 2 article on databese UTHM JTET. The keyword search resulted in 348 articles for further selection.

Next, the titles and abstracts has been reviewed to select a number of articles or papers by specifying selection that met the following criteria:

- Focus teaching and learning on power electronics course
- Year published from 2011 to 2017
- The title of the article should be one such word: power electronics, teaching/teach, instruction, learning, strategies, methods, e-learning and science education
- The abstract briefly describes one such word: power electronics, teaching, learning, e-learning and innovation education power electronics
- Peer-reviewed articles
- Full text written in English
- Empirical research, teaching and learning on power electronics
- Have digital object identifier
- Could be downloaded (electronic format)

The following is the systematic steps taken in conducting literature studies as shown in Figure 1.

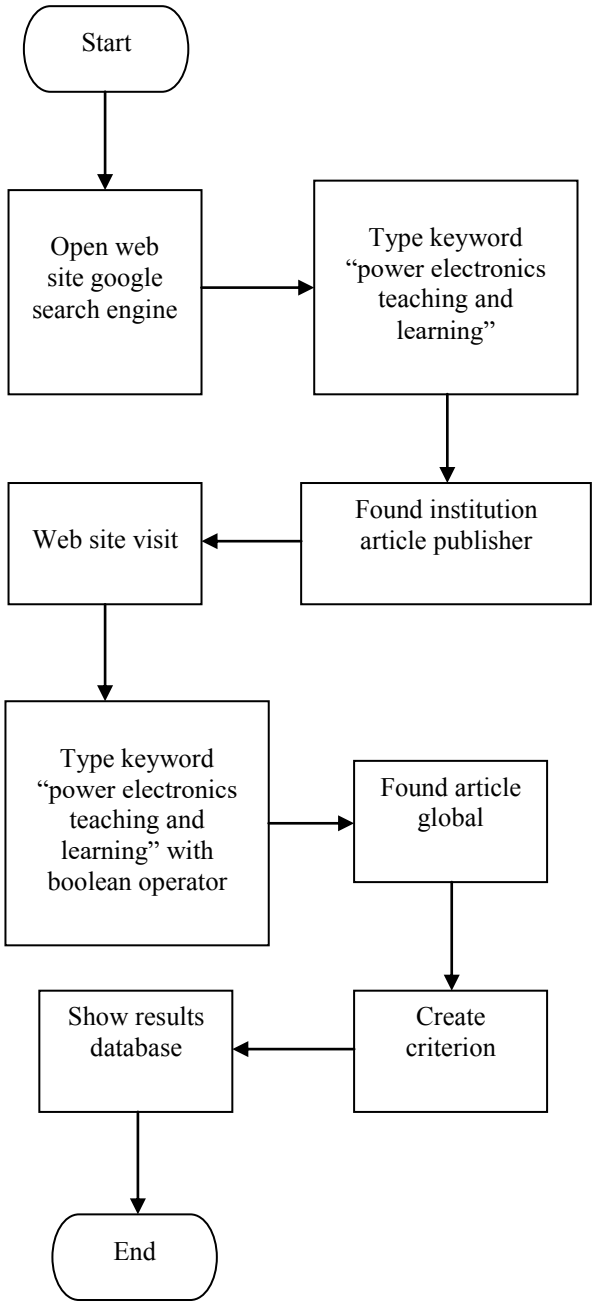

Fig. 1. Flow chart systematic literature of review

After selection and screening, based on the articles criteria that meet the requirements for literatured review, on each database of website pages. The final articles show by figure 2. The total of 39 articles that became the source of the reading for review, most published in 2015 as many as 10 articles, 2014 as many as 8 articles, 2013 as many as 8 articles, 2016 as many as 6 articles, 2012 as many as 4 articles, 2011 as much 2 articles and until 2017 as much 1 article. There are several authors who have more than 1 article. This final data totals are re-verified to ensure that a number of articles meet the criteria specified for review. All articles are then re-read.

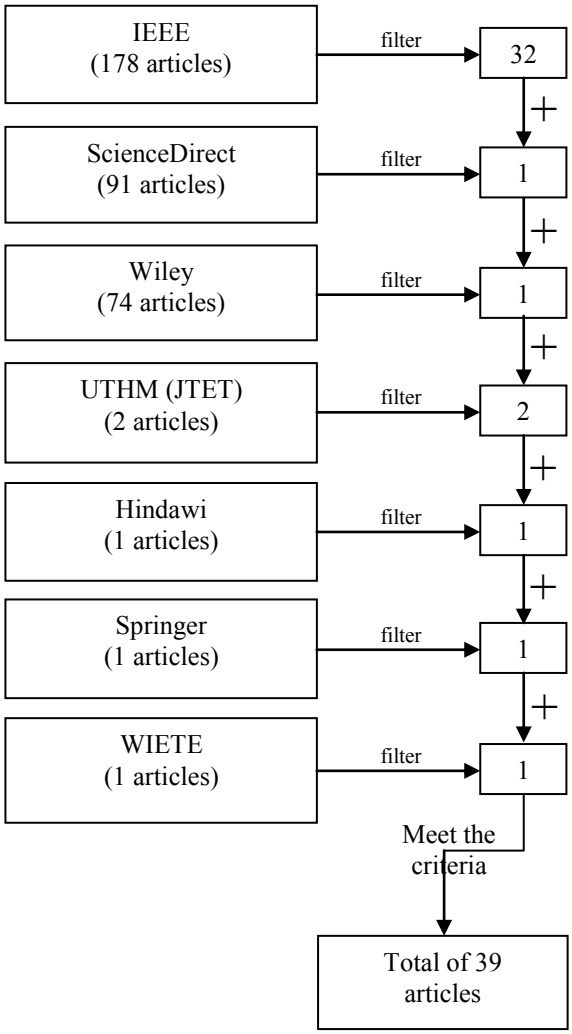

Fig. 2. The total number of articles in review

IV. Results And Discussion

The results in the literature review explained that teaching and learning on the power electronics course found many problems and of course various solutions. The problems such as traditional teaching method (lectures), most universities do not build experimental laboratories equipped with standardized equipment likes in the industry because of a lack of budget, teaching and learning are less effectively and efficiently, low motivation of students in attending lectures, low average student scores, the number of students who repeat (remedial) and etc. The solutions such as teaching and learning with project-based learning, problem-based learning, teaching method with do-it-yourself and etc. More detail on the results from these literature review was summarized as shown in table 1.

TABLE I. Problem And Solution Teaching And Learning On Power Electronics Course

No.	Teaching and Learning on Power Electronics Course		
	Author (s)	***Problem***	***Solution***
1.	[13]	Costly to build a power electronics laboratory like the one in the industrialized world.	Developing hardware as a module for teaching topologies, controllers, and functionalities material on Power Electronics and Drives Experimental Bench (PEDEB)
2.	[14]	Traditional teaching methods such as lectures use of microsoft power point media and educational learning approaches	Project-based teaching method with a laboratory workshop in the industry (project based learning and problem based learning)
3.	[15]	The teaching of power electronics difficult to do modelling of learning the power electronics course	Implementing a teaching strategy with a project-based learning model that involves at least two different fields of science such as power electronics and communication systems
4.	[16]	The equipment available in the laboratorium is outdate	Using meta models for experimental and electromagnetic compatibility simulation modeling
5.	[17]	Student low level of participation in learning to interact, interaction and interactivity	The teaching method innovation with meaningful learning theory by David Ausubel in combination with sociohistorical learning theory by Lev Vygotsky using multimedia software Adobe Flash CS5.
6.	[18]	Most universities do not build experimental laboratories equipped with standardized equipment likes in the industry because of a lack of budget Limited number of hours in the classroom and class practice	Computer simulation on controller material for DC motors with Sliding Mode Control (SMC) techniques involving artificial intelligence for optimization such as Fuzzy Logic (FL), adaptive neuro fuzzy inference systems (ANFIS), and Genetic Algorithms (GAs)
7.	[19]	Students have little time to interact with the power electronics laboratory, as a consequence their competence is limited	Developing a virtual laboratorium based B-learning models consist Of combination lecturer in the classroom, self-study sessions, quizzes, design, issues, emulation issues and on-line laboratory sessions.
8.	[20]	Most students are less interested in the monotonous teaching style	Using a project based learning model with syntax as follows: 1) Divide heterogen-eous work groups, presentations and assignments.

No.	Teaching and Learning on Power Electronics Course		
	Author (s)	*Problem*	*Solution*
			2) Explain the safety material in the practice room laboratory 3) Seminar and using simulation software 4) Projectdevelopment and project appraisal
9.	[21]	The laboratory system for engineering education are limited resources for improving engineering students practical knowledge as well as self learning ability.	Developing of virtual laboratory that can be accessed remotely from any place and anytime with collaboration project and problem based learning
10.	[22]	The mainly teacher centered learning approach, lack of practical knowledge of engineering students has become a major concern of the engineering faculty	Teaching with web-based learning via LabVIEW and MATLAB
11.	[23]	Students low final semester exam score over the last three years, from 2010-2012 at University Tenaga Nasional (UNITEN) Malaysia	Problem based learning method of combining teacher centered learning with the student center learning approach
12.	[24]	The low number of graduates received work in industry	Conducting a combination teacher center learning method with simulation and experiments based methods
13.	[25]	On-line learning method that is done by educators through the internet is not enough to meet the aspects of interaction between educator- material-learners and fellow learners	The new pedagogical concept that was used is called Hybrid or Partially Flipped Classroom. Pedagogy in which active student engagement is facilitated through both on- line and face-to-face lecturer methods.
14.	[26]	Teaching method with black-box is to inflexible and there is no real insight into the design process and have been to incorporate experimental learning	A modular learning method called PEGO (Power Electronics to GO). PEGO consists of two modular blocks of theory and practice.
15.	[27]	Costly to build a power electronics laboratory like the one in the industrialized world	Virtual lab strategies for power electronics course
16.	[28]	The rapid development of power electronics technology makes the existing equipment in the laboratory room is now becoming frequently obsolete.	Interactive learning management system with 3- D simulation application (3- D TCAD). The LMS will be accessible from the educational portal using Moodle
17.	[29]	A teacher center learning method that has increasingly made the declining motivation learner's	The use of a simulation software model of the power electronics course that was served to narrow the scope of the topic for discussion

No.	Teaching and Learning on Power Electronics Course		
	Author (s)	*Problem*	*Solution*
18.	[30]	Students low motivation and interesting to explore the content in the class room	Applying project based learning method with a student center learning approach, cooperative learning type jigsaw, experiment based learning and assess using portfolios or rubrics
19.	[31]	The gap between theory and practice to promote the transfer of knowledge	A project based learning model and a specific scenario for promoting active learning in power electronic education
20.	[32]	Students had difficulties in completing the project work given by the teacher college just in time	A Project Oriented Problem Based Learning (POPBL) to improved cognitive, affective and skill students at the Faculty of Electrical and Electronic Engineering, UTHM, Malaysia
21.	[33]	Educators have difficulty in delivering abstract content knowledge such as how current flows AC voltage controllers works	Using software packages such as MATLAB, PSPICE and PSIM for class room teaching strategies
22.	[34]	Students have not gained sufficient knowledge and experience to learn about embedded systems such as the use and utilization of hardware and software in a single package	Using Arduino Uno to teach power electronics on digital control material
23.	[35]	Unavailability of a feature simulator learning application on power electronics	Developing LMS with additional simulator features and combined with GeckoCIRCUITS
24.	[36]	Students have difficulty understanding content abstract material	Teaching based on forecasts and self-assessment learning
25.	[37]	The decreased motivation to learn that can be known from the perception of learners who consider the learning difficulty	Teaching based on Project based learning
26.	[38]	Students are not able to developed a model, design, and apply it in work industry	Teaching and learning with project + problem based learning
27.	[39]	Learning on power electronics course is not optimal	Teaching with concept maps using CMAP tools software
28.	[40]	Teacher centered learning methods are less able to improving learning outcomes of learners	Developing LMS Moodle, Blackboard and eCampus based on multimedia interactives and virtual laboratories
29.	[41]	Teacher centered learning methods with multimedia CD interactived are not able to improving learning outcomes	Teacher centered learning combined with Lotus Learning Management System (LLMS)
30.	[42]	Students are less able to understand the concept of power electronics on the converter material	Developing PLECS simulation as a models of teaching with Matlab

No.	Teaching and Learning on Power Electronics Course		
	Author (s)	*Problem*	*Solution*
31.	[43]	Students have difficulty in understanding abstract material.	Developing experimental teaching and learning methods
32.	[44]	Traditional teaching methods such as lectures with using slides and explaining on the blackboard are less effectively	The combination of traditional teaching methods with multimedia interactive tools
33.	[45]	Teacher centered learning approached less able to encourage students independent study and active participation	Developing the educational software as like learning manage-ment system (LMS) in the teaching/learning process.
34.	[46]	The huge amount of information available may lead to confusion that students may encounter creates a need for goals to be learn and stress levels caused	Stepping into a new learning environment from virtual to personal (Personal Learning Environment/PLE)
35.	[47]	The diversity of the concepts provided in the curriculum, it is very difficult for the students to acquire a comprehen-sive picture of power electronics and electronics, electrical engineering, and other domains	Developing learning content management system (LCMS) and concept maps with as a sub-system of the repository of Estonian National e-Learning Portal and self-assessment
36.	[48]	A survey of engineering students shows that experiments that have been done with teacher centered methods for inverter materials are less able to improve their understanding and interesting	Developing outcome based learning (OBL) method with kit includes signal generators, power inverter and load
37.	[49]	The laboratory applications cant give expected successful results because of insufficient laboratory environment of educational institutions and etc	Developing web-based virtual power electronics laboratory
38.	[50]	Student low interesting and communicating with teacher- centered learning	Developing theoretical instruction in practical teaching to make sure students "to know truly is to know by cause" and to train them to get the ability
39.	[51]	Teacher centered learning approached less able to improve teaching effectiveness in power electronics course, to develop students' ability to transfer theoretical knowledge into industrial practice	Developing Project-Based Learning (PBL) approach in PEI by distributing the core elements across the four main course subjects.

Based on table 1, we seek there are four main aspects that become gap or constraint on the process of teaching and learning. First, the ability of educator to innovated in learning as many as (20 articles). Second, the limitation of physical infrastructure resources as many as (11 articles). Third, the low motivation of student college learning as many as (6 articles). Fourth, the curriculum content (2 articles). Figure 3 will showed the percentage of article review according to these four aspects.

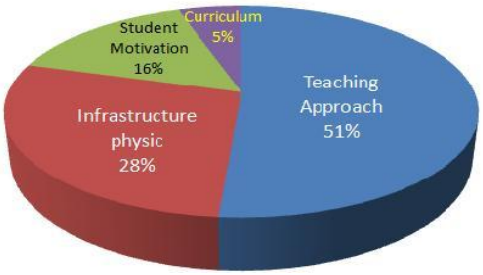

Fig. 3. Percentage the problem of teaching and learning

According to table 1, we classified solutions teaching and learning into 4 categories, such as the models of teaching (12 articles), strategies (8 articles), methods (14 articles) and techniques (5 articles). Percentage the solution of teaching and learning on power electronics course showed on figure 4.

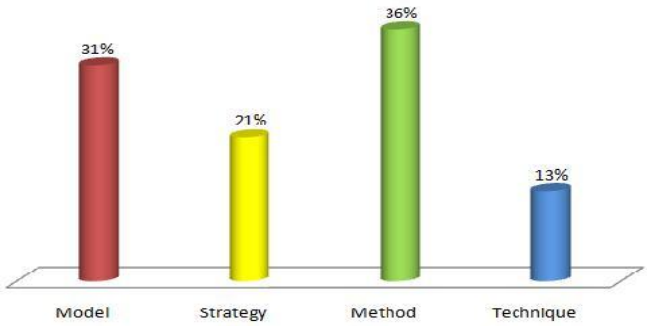

Fig. 4. Percentage the solutions of teaching and learning.

V. CONCLUSSION

In this review of the literature presented collection problem and solution to teaching and learning on power electronics course. Based on the findings, it is evidence that the educators had been done various ways as solutions in achieving learning goals in all limitations. It offers a pedagogical model, strategy, method and technique that has a potential to engage both teachers and learners in meaningful educational experiences. Educators must be able to improve students' abilities cognitive, affective and psychomotor. Further research is required to be more complete that what should be done in the future.

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