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Curriculum Reconstruction for Education and Training of Electrical Engineering For Construction Employment in Indonesia

M Ali

Department of Electrical Engineering Education, Faculty of Engineering, Universitas Negeri Yogyakarta

Corresponding author: muhal@uny.ac.id

Abstract. The main objective of this article is to discuss curriculum reconstruction for education and training in the electrical engineering field on building construction work. The curriculum review process is intended to meet the requirements of industrial construction and enhance the employability of students to do the job in electrical engineering field. The method used is Dacum (Developing a Curriculum) by systematically analyzing positions through brainstorming with experts in construction companies and electrical engineering education. The curriculum has been reviewed extensively in order for the program to be more relevant and focused on the needs of the program. The results showed the curriculum that needed to be developed in educational and training institutions in the electrical engineering field on a construction job can be divided into three (3) types of job positions, are 1. Electrical job planners, 2. Electrical job inspectors, and 3. Electrical Job implementers.

Keywords: curriculum development, education and training, electrical engineering, construction employment

1. Introduction

As a developing country, Indonesia needs development in all fields to improve the welfare of society, especially in infrastructure. Inadequate infrastructure conditions are one of the factors why Indonesia has not moved from developing countries to developed countries [2]. Infrastructure development is one of the factors increasing the Indonesian economy which can be seen from the large percentage of the construction sector of Indonesia's Gross Domestic Product (GDP) of 10.36% [3] (BPS, 2018). Infrastructure is a collection of facilities deliberately created to facilitate human activities [2, 3]. During the administration of President Joko Widodo, various infrastructures have been built including airports, ports, dams, irrigation, arterial roads, toll roads, clean water, sanitation, bridges, power plants, housing, and other infrastructure contribute to increasing Indonesia's competitiveness [2]. One instructor of concern is the construction of buildings that are used both for offices, shopping, and housing.

Building construction work is a complex work that involves building materials, equipment installation, labor and the application of technology that can be a source of work accidents and even death and material loss. Construction work must be carried out with due regard to safety, security, comfort and environmental sustainability. For this reason, good collaboration is needed from various qualified human resources in the fields of civil engineering, architectural engineering, electrical engineering, and other related fields of science and technology. In reality, many workers in electrical engineering fields in construction work do not have the appropriate education. As a result, many



electrical jobs are handled by people who actually do not have the appropriate educational background. This makes the quality of electrical work in building installations not optimal. Many cases, buildings that have electrical installations that do not meet the standards [1]. This has the potential to cause occupational accidents and fire hazards. The National Disaster Management Agency (BNPB) stated that during 2018, there were 951 building fires of which 70% were caused by electricity problems [9, 10, 11].

To overcome the problem of labor quality, some construction companies set up vocational education and training institutions in the electrical sector to provide training to workers [1]. Teachers are drawn from senior workers who have experience and companies supplying electrical equipment. One of the main problems of company training institutions is related to the curriculum. Most curricula are arranged in an original way based on the experience of senior workers, most of whom do not have an educational background that is appropriate to the field of electrical engineering. Curriculum development is based on good experience in carrying out electrical work in buildings without academic studies on the depth and breadth of the material to be taught. The timing of the training is also based on estimates only.

For this reason, the management of construction companies feels the need to improve the quality of education and training by conducting collaborative curriculum development in the field of electrical engineering with universities. Collaboration starts with redesigning the curriculum, developing training materials, developing learning media and testing instruments. This reconstruction curriculum is expected to be able to provide the knowledge, skills and work attitudes needed by electrical sector workers in the building construction industry. The involvement of TVET education in developing education and training institutions in the industry is one of the efforts to improve the quality of human resources. This article aims to reconstruct educational and training curricula in the electrical engineering field industry in building construction work.

2. Curriculum Reconstruction

2.1. Curriculum Development

Finch & Crunklinton [4], [5] defines curriculum as a collection of activities and learning experiences that must be experienced by a group of students under the direction and responsibilities of the school. The curriculum consists of all the experiences children have under the guidance of the teacher [1, 17]. In-Law No. 20 of 2003, Government Regulation No. 19 of 2005, the curriculum is seen as a set of plans and arrangements regarding the objectives, content and learning materials, the method used to guide the implementation of learning activities to achieve certain educational goals. The concept of the curriculum contains two aspects that need to be considered in education and training are: 1) The main focus of the curriculum is students, 2) The curriculum is not only a collection of subjects to be followed by students, but includes all activities that have a significant influence on the formation of participants students in total and achieving effectiveness.

Curriculum development is described as the process of planning, building, implementing, and evaluating learning to produce the desired changes in students [21]. Educational and training institutions need to develop curriculum and training tools with quality that meets the standards and is relevant to the job [20]. Curriculum development is generally carried out through a systematic approach with the main activity being curriculum development, then selecting program content, learning strategies, and assessment methods [4]. This approach is often conceptualized as an iterative cycle consisting of five phases: analysis, design, development, implementation, and evaluation [17]. Kessels explained that a relational approach that involved stakeholders in the curriculum development process was also needed to ensure curriculum responsiveness to the needs of related stakeholders [6]. This relational approach centers on extensive collaboration and consideration between curriculum developers and stakeholders throughout the development process to reach consensus on the main features of educational programs, such as outcomes, content, pedagogy, and assessment [19].

The systematic and development related uses for TVET curriculum development are based on unique features and focus on providing a direct learning experience for students. After completion, students with the knowledge, skills and work attitudes needed to succeed in the world of work. Responsive to

changes in the needs of society and the labor market [6, 20]. Education and training curriculum becomes a challenge for competent managers who will assume curriculum competencies that have goals. Academic managers are increasingly expected to undertake curriculum leadership tasks, support and share goals, support external and internal collaboration with curriculum stakeholders, provide structure for curriculum development work, and coordinate various complex curriculum development activities [20].

2.2. *Electrical Engineering Job*

Law No. 30/2009 concerning Electricity states that every technical person in the electricity business must have a competency certificate. Article 19 of Government Regulation No. 62 of 2012 concerning Electricity Support Services Business explains that the Competency Certificate is given by the Competency Certification Agency which is accredited by the Minister of Energy and Mineral Resources where the Competency Certification is carried out by the Electricity Assessor. Competency Certification is one of the mechanisms in the application of Electricity Safety to realize the conditions of electric power installations that are safe, reliable and environmentally friendly.

The job of an electrical engineer in building construction work is to design building protection systems from lightning strikes, design electrical buildings that include sources of electrical energy, electrical power distribution, protection of electrical equipment, lighting and lighting installations, electrical equipment power supply installations, air conditioning installations, elevator and escalator installation and communication device installation [12, 13]. In the construction industry, an electrical engineer has the role of surveying locations and managing the design and construction of electrical systems so that they comply with established codes and standards. Electrical engineers are responsible for designing, testing, installing, and maintaining electrical systems in buildings. In design, it is necessary to calculate project costs and schedule the delivery of material for supplies. At the end of the project, the electrical engineer is responsible for ensuring that all standards are met.

Electrical engineering is a technical discipline related to studios, design, and application equipment, devices, and systems that use electricity, electronics, and electromagnetism [14, 15]. Modern buildings require electrical devices such as lighting, air conditioning, power installations for electrical equipment such as computers, televisions, refrigerators, washing machines, air pumps and so on. For this reason, electrical work in building construction needs to be carried out by experts in the field of electrical engineering to ensure the security and safety of its work. Electrical work involves planning, implementing and testing and commissioning work. The work of lightning installation planning, lighting installation planning, energy installation planning, TV, radio and data installation planning, air conditioning installation planning, and protection planning [1, 15]. Installation, installation of contacts, pipe installation, cabling and installation of measuring and safety equipment. While testing and commissioning include testing of electrical installations in accordance with the provisions of standards and regulations.

3. Method

The method of curriculum development and learning devices in electrical engineering fields expertise in building construction work uses the DACUM approach which consists of 8 steps are: 1) Job profile Analysis, 2) Learning outcomes of the Profession, 3) Field of Training, 4) Forming of courses, 5) Preparation of depth and breadth of the education and training, compilation of curriculum structure, 6) Training design and method, and 7) Assessment method. In brief, the stages in preparing the curriculum and learning tools of Education and Training can be seen as Figure 1.

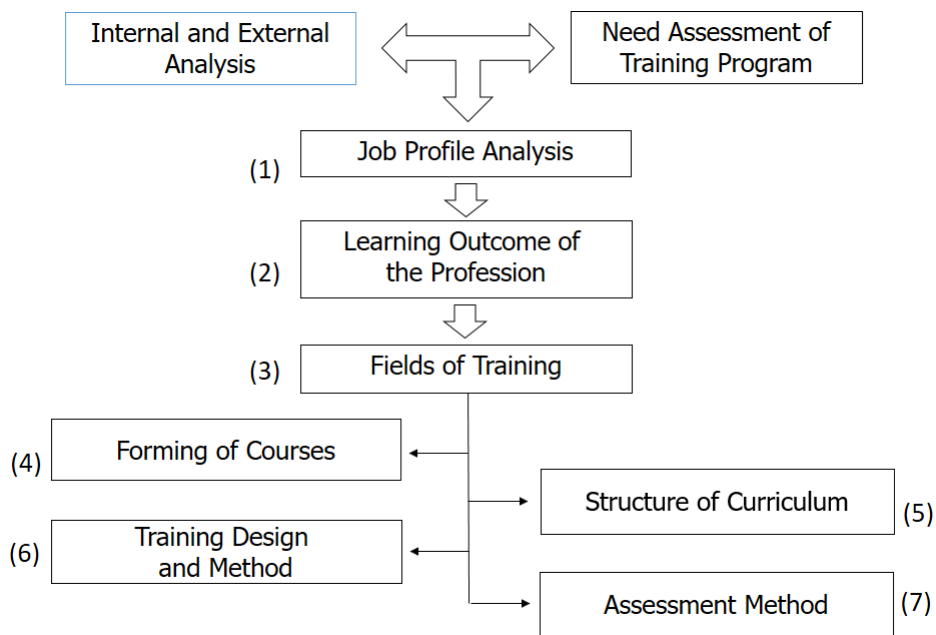


Figure 1. Curriculum Development Approach.

Curriculum development is carried out by involving electric power engineering education experts from Yogyakarta State University and several construction companies in Indonesia. The curriculum preparation begins with a Focus Group Discussion (FGD) to conduct self-evaluation analysis with the SWOT method to map strengths, weaknesses, opportunities, and threats. The FGD was also carried out to identify the workforce needs of a building construction company to be a superior company in its field. FGD activities are expected to result in the identification of job profiles, main tasks and work competencies needed to achieve the company's vision and mission. From this data, curriculum and learning tools are then arranged.

4. Result and Discussion

4.1. Result

Curriculum development is carried out by involving electric power engineering education experts from Yogyakarta State University and several construction companies in Indonesia. The curriculum preparation begins with a Focus Group Discussion (FGD) conducted at industries and on the campus of UNY to conduct self-evaluation analysis with the SWOT method to map strengths, weaknesses, opportunities, and threats. The FGD was also carried out to identify the workforce needs of a building construction company to be a superior company in its field. FGD activities are expected to result in the identification of job profiles, main tasks and work competencies needed to achieve the company's vision and mission. From this data, curriculum and learning tools are then arranged.

Table 1. Job.

No.	Job	Main Task	Competences	Learning Modul
1.	Electrical Planner	<ul style="list-style-type: none"> • Design in detail electrical engineering with a safety factor • Design of Lightning protection system for building • Lighting and illumination design and lux calculations 	<ul style="list-style-type: none"> • Able to design engineering plan with a Safety factor • Able to design earthing of electrical installation • Able to design lighting and illumination 	<ul style="list-style-type: none"> • Electrical Drawing • Electrical Material • Device and Electrical Measurement • Standards and Quality of Electrical Work • Electrical Analysis

No.	Job	Main Task	Competences	Learning Modul
		<ul style="list-style-type: none"> Design and calculate cable size, scheduling, and its route Design of the protection systems Electrical installation design. Fire alarm and detection system design Design and calculate air conditioning systems Design radio and data communication installation Design of earthing in electrical installation 	<ul style="list-style-type: none"> Able to analyze the electrical material Able to design Electrical Protection system Able to design Electrical Installation Able to design Air Conditioning Able to design Radio and data communication installation 	<ul style="list-style-type: none"> Electrical Power System Planning Electrical Installation Planning Electricity Work Quality Standards
2.	Electrical Inspectors	<ul style="list-style-type: none"> Make a weekly job planning Identify job incompatibility with standards Prepare inspection work reports Oversee Occupational Safety and Health (OSH) at work Coordinates with others for any site instructions and inspection of works. Interprets construction drawings and studies the contract documents Estimates prepare and assign resources (manpower, materials, equipment, tools, etc.) Checking the Workmanship and material Quality Ensures that all site works are done according to all applicable quality standards Review inspection reports and records of Quality Control. 	<ul style="list-style-type: none"> Able to make job planning. Able to identify job incompatibility with standards Able to do OSH Able to coordinate with others Able to Interprets construction drawings and studies the contract documents Able to Estimates prepare and assign resources Able to check the Workmanship and material Quality Able 	<ul style="list-style-type: none"> Electrical Drawing Electrical Material Device and Electrical Measurement Standards and Quality of Electrical Work Electrical Analysis Electrical Installation Planning Electricity Work Quality Standards
3.	Electrical Job Implementers	<ul style="list-style-type: none"> Carry out electrical work in accordance with the work drawings Install Lightning protection system for building Install lighting and electric power installations according to design Plans the execution of all electrical related works and coordinates the works to mechanical and civil groups Interprets construction drawings and studies the contract documents and standards Coordinate with others for electrification, execution, erection, and commissioning 	<ul style="list-style-type: none"> Able to read electrical engineering drawings Being able to choose quality electrical equipment materials Able to install electricity according to standards Able to plan work implementation Able to interpret work drawings according to contract documents and standards Able to coordinate with contractors for electrification and commissioning 	<ul style="list-style-type: none"> Basic Electrical Electrical Drawing Standards and Quality of Electrical Work Electrical Drawing Electrical Material Device and Electrical Measurement Standards and Quality of Electrical Work Electrical Analysis Electricity Work Quality Standards

In addition to skills in the field of electrical engineering, workers in construction work also need to be equipped with knowledge and skills in communication, time management, and complex problem-solving skills. The combination of soft skills and hard skills can be very needed in electrical work in building construction. Based on the assessment of the job profile, the competencies needed for each electrical work in building construction, then compile a list of subjects and the number of hours of study.

The following are subject data developed in the field of education and technical training for building construction work.

1. Quality Control in Electrical Work Module consist of 4 sub-module are:
 - a. Basic Electrical,
 - b. Electrical Equipment Material,
 - c. Electrical Measuring Instruments,
 - d. Standards and Quality of Electrical Work
2. Electrical Work Planning and Calculation Module consist of 3 sub-module are:
 - a. Basic Electrical Calculations
 - b. Electrical Installation Planning
 - c. Electricity Work Quality Standards
3. Method of Conducting Electrical Work Module consists of 3 sub-module are:
 - a. Implementation standards for Electrical Work
 - b. Electrical Distribution Work Methods
 - c. Electrical Installation Testing and Commissioning

4.2. Discussion

The reconstruction of the education and training curriculum in the field of electric power engineering for building construction work has been successfully carried out. This activity involves electrical engineers from various construction industries, electrical engineering engineers, academics from universities and students. This curriculum is expected to be applied to educational and training institutions to provide provisions and additional knowledge to building construction workers in the field of electrical engineering. Along with curriculum reconstruction, education and training tools were also developed in the form of training modules, instructional media, training videos, and training evaluation instruments.

This reconstruction curriculum is expected to be one of the solutions to overcome the problem of the lack of competence in electrical engineering in building construction work. Of course, this curriculum needs to be continuously developed in accordance with the development of science and technology in the field of construction and electrical periodically. Modules, videos, training evaluation instruments must be reviewed at least every two years to ensure the competency of trainees in accordance with the needs of the desired work, especially in the era of the industrial revolution 4.0. The next stage that needs to be done is to implement the results of curriculum reconstruction and conduct an evaluation. The results of the implementation and evaluation can be used as a barometer to improve the curriculum in the future. There is no perfect education and training curriculum, but it always needs improvement over time in order to find compliance with what is expected.

To ensure the successful implementation of the curriculum of the results of reconstruction, it needs to be accompanied by training of teaching staff on learning methods and evaluation of learning outcomes [1, 22]. The curriculum must be a blueprint for education and training activities so that other aspects of education and training must adjust the curriculum design. Curriculum related matters that need attention include:

- Improve Training Method
The method of delivering material from the instructor to students must adjust to the characteristics of students [20, 16]. Most students are workers whose average age is between 20 and 45 years, so instructors need to understand learning for adults (andragogy). Material delivery methods also need to adopt interactive computer-assisted learning media and smartphone applications that are currently

trending. Work-related learning videos need to be presented at the training to provide a visual representation of the material to be taught.

- Improved evaluation system

One important aspect of curriculum development is the learning outcomes of students. For this reason, it is necessary to develop an evaluation system that allows instructors to see students' progress towards the material being taught. Evaluation instruments can be developed in the form of tests and non-tests according to training needs [1, 19]. Evaluation instruments must be developed in accordance with the objectives to be achieved and the characteristics of the expected competencies.

- Cultivation of Generic Skills

Electrical engineering work has a very close relationship with professionalism, health, safety, the environment, ethics, and standards, therefore training participants need to be cultivated in a work attitude that supports work. Communication skills, critical thinking, problem-solving, teamwork, and other soft skills [22].

5. Conclusions

The curriculum reconstruction for Education and Electrical Engineering Training for Construction Work in Indonesia was successfully carried out in accordance with the needs of the various interests of the building construction industry. The program of structural education change and technical training provides the quality standards required by the construction industry in Indonesia. The depth and breadth of the training material in accordance with the competencies needed for each job profile. Learning materials and media need to be developed continuously in accordance with the development of science and technology. By agreeing to this curriculum, it is hoped that there will be an increase in the quality of culture to ensure the programs offered are highly relevant to current technological developments, especially in the industrial revolution era 4.0.

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