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Implementation of Electrical Engineering Curriculum in the Era of Industry 4.0 in Indonesia: Stakeholder Participants Qualitative Interviews

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ABSTRACT

The rapid development of science and technology has led to fundamental changes in terms of qualifications, competencies, and requirements to enter the industrial world. This has led to the adjustment of the effectiveness of collaboration between industry and higher engineering education, thus necessitating further consideration of engineering higher education curricula that are oriented towards the industrial revolution. The aim of this study is to examine how the electrical engineering curriculum can be adjusted and improved to be more relevant to the technological advancements and industrial demands of the Fourth Industrial Revolution era in Indonesia. This qualitative descriptive study utilizes the Focus Group Discussion (FGD) method and semi-structured online interviews. Stakeholder participants including the heads of Electrical Engineering programs in the top twenty universities in Indonesia have been involved in this study. We explore perspectives on the implementation of the electrical engineering curriculum, its rationale, objectives, methods, and challenges in its execution. Herewith, curriculum revisions are deemed necessary while still adhering to the fundamental principles based on accreditation institution guidelines. The findings highlight that incorporating the latest technologies with a focus on practical skills relevant to the development of Industry 4.0 is essential. The latest technology supporting practical skills for electrical engineering students needs to be improved. Active involvement from all parties in the curriculum implementation is the key to producing competent graduates prepared to face global challenges in the era of the Fourth Industrial Revolution.

Keywords:
Electrical engineering curriculum; Implementation of technical curriculum; Industrial revolution 4.0; Stakeholder qualitative interview

1. Introduction

The development of digital technology has significantly impacted the world of education [1,2]. Adopting advanced technologies such as artificial intelligence, big data, the Internet of Things (IoT), and machine learning cannot be avoided [3-11]. The methods of learning and teaching processes in

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higher education have undergone transformation [12-15]. Digital technology enables the use of online learning platforms, e-books, video tutorials, and interactive tools that enrich students' learning experiences, facilitates distance learning, and provides access to various educational resources from around the world [16-19]. Many reports on the use of digital technology have been well-documented [20-29]. Additionally, data analysis and artificial intelligence tools can assist instructors in understanding individual students' needs and providing more personalized guidance.

One of the key pillars of the United Nations' 2030 Sustainable Development Agenda is to achieve quality, inclusive, and equitable education [30]. In pursuit of this goal, digital technology has become a crucial tool. Its strong influence on educational curriculum has been further confirmed, especially after the COVID-19 pandemic, which accelerated the adoption of digital technology in learning [31-33]. This technology has transformed the paradigm of education, serving not only as a knowledge provider but also as a co-creator of information, a mentor, and an evaluator.

The advancement of technology in education has provided significant benefits to students, with the use of software and tools that facilitate the creation of presentations and projects [34-36]. Devices such as iPads have replaced stacks of books, and e-books have also simplified the research process [37,38]. All these innovations contribute to increasing students' interest in the learning process. The digital learning approach, by reducing the use of paper for handouts and textbooks, offers significant advantages. Besides cost reduction, this approach also utilizes resources efficiently, supports sustainability efforts, and expands the impact and reach for both students and lecturers [39,40].

However, challenges also arise along with the technological advancements in the field of education [41]. These include the technology access gap among students from various economic backgrounds, the need for time adjustment in adopting digital technology in learning, the implementation of digital technology in education posing risks to student and faculty data security and privacy, as well as challenges in the curriculum adaptation [42,43]. The implementation of digital technology in the world of education needs to be supported by appropriate policies that can be incorporated into curriculum policies to ensure its effective and sustainable utilization in creating an innovative educational system [44,45]. Many reports regarding curriculum have been well-documented [46-53]. Here, this research aims to gain insights into the curriculum implementation concerning feasibility, challenges, and the supporting factors of using technological advancements in the field of education, especially in electrical engineering education during the Fourth Industrial Revolution era.

2. Methodology

To conduct the data collection process and determine the prioritization criteria for the Electrical Engineering Education Program in the Fourth Industrial Revolution era, we conducted a Focus Group Discussion (FGD). This qualitative descriptive research [54-56] involved semi-structured interviews with stakeholders who participated as resource persons. In the initial stage, we invited the resource persons via email, with an invitation letter and a proposed schedule for the FGD attached. Some of resource persons did not respond to the email invitations, while others did. The resource persons who responded to the email invitation were then followed up and sent a second email with an attached letter of consent to participate in the FGD. Nine resource persons (both male and female) consented to participate and attended the FGD.

FGD was employed as a method to acquire data regarding the implementation of the Electrical Engineering curriculum in the industry 4.0 era in Indonesia. Structured and guided stakeholder participants of the FGD shared their experiences, perspectives, and understandings concerning the relevant electrical engineering curriculum in alignment with the advancement of Industry 4.0 technologies. The FGD also provided in-depth insights into challenges, opportunities, and needs in the development of a curriculum that was responsive to the requisites of Industry 4.0. Additionally, it aided in designing enhancements and adjustments to the curriculum that were pertinent. This facilitated the attainment of a more comprehensive understanding of their outlook towards the existing curriculum, and how it could be tailored to the evolving technological landscape and industrial demands.

The interviews were conducted in two sessions, through audio and video recordings using the Zoom Meeting platform on different dates and days. Each interview session lasted for approximately 120 minutes. The interview session on the first day, May 29 2023, was attended by four participants, and the second-day interview session on June 1 2023 was attended by five different participants. There was no re-interview session after the discussion. The researchers acted as moderators to facilitate the FGD by explaining the purpose and objectives of the discussion, presenting the topics, and outlining the procedure for the discussion. In designing the forum, the researchers examined the experiences of stakeholders as interviewees. The interviewees consisted of the Head of the Electrical Engineering Study Program and expert faculty members who possessed deep understanding of the curriculum domain at the top twenty universities in Indonesia.

The discussions during this FGD encompassed curriculum objectives, teaching methods, and obstacles to curriculum implementation. Questions were posed to the interviewees to obtain their responses regarding the challenges of the electrical engineering higher education curriculum in the industry 4.0 era. The researchers aimed to effectively elicit insights from the interviewees on how the electrical engineering higher education curriculum can be aligned with the requirements of Industry 4.0 [57].

Analysis was carried out based on the transcribed interview data. The aim of this analysis process was to identify significant information that emerged during the discussions. We meticulously coded the transcripts to search for relevant phrases in accordance with the themes and examined the contextual relationship between the information provided by the interviewees. By comprehending the interviewees' perspectives, this aided us in delving deeper to unearth insights about the higher education electrical engineering curriculum's responsiveness to Industry 4.0 needs. The outcomes of the analysis following the interviews and transcriptions play a pivotal role in formulating accurate findings, conclusions, and recommendations based on real data. These outcomes also serve as a foundation for further research.

3. Results

Twenty people were invited to attend the forum, and nine people agreed to be participants (Refer to Table 1 for demographics and Figure 1 for the recruitment flow).

Table 1
Participant Demographics

Demographics	Count (N)
Gender	Male = 8 ; Female = 1
Forum attended	F1=4 ; F2=5

(F1= attended forum 1; F2= attended forum 2 ; P=Person)

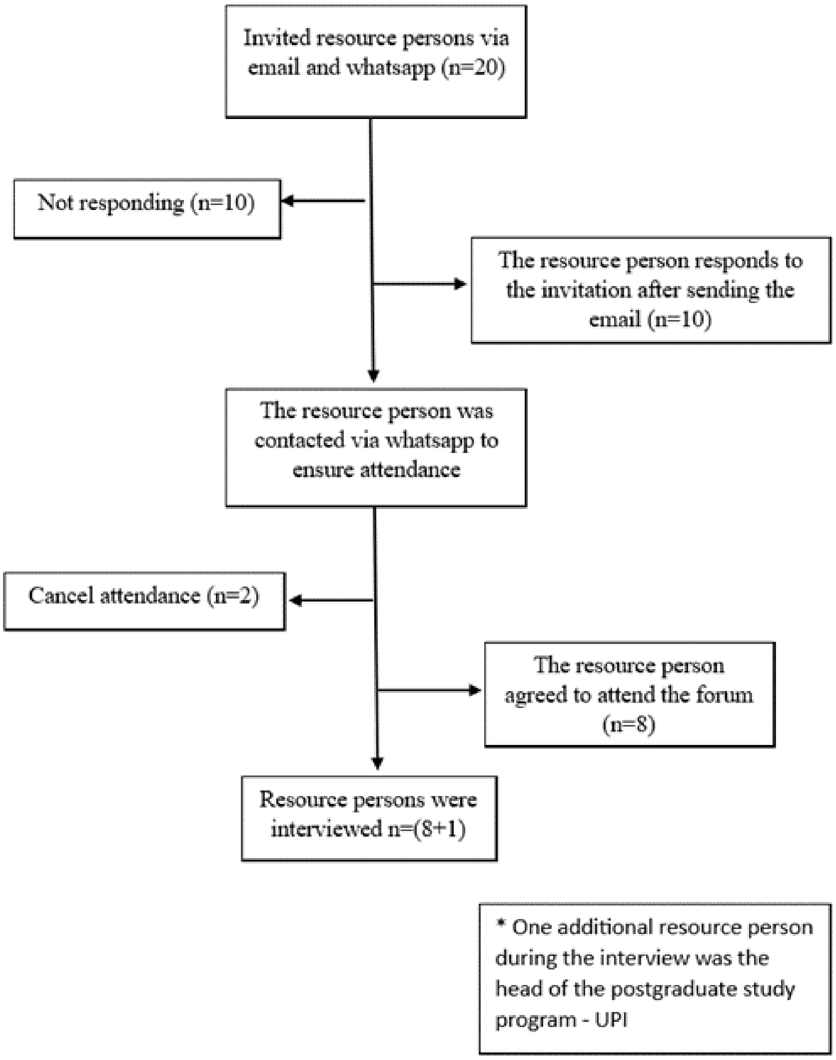

Fig. 1. Resource persons invitation diagram

Meanwhile, the identified theme is as follows:

3.1 Curriculum Objectives for Higher Education in Electrical Engineering in Indonesia

During the conducted FGD that deliberated upon the objectives of the Higher Education Electrical Engineering curriculum in the context of Indonesia's Industry 4.0 era, resource persons will collaboratively engage in discussions to identify curriculum needs and challenges in confronting the 4th Industrial Revolution. Discussion stakeholder participants are well-versed in engineering curriculum objectives to align with the technological advancements of the industry 4.0 era. Various approaches have been undertaken, albeit with slight methodological differences. Nevertheless, they adhere to the regulations and standards established by the government. Some of the speakers have mentioned that they have revised the electrical engineering curriculum in response to the developments of the industry 4.0 era.

"*This revision mainly focuses on the basic science fields…where physics and mathematics form the foundational knowledge that students must acquire during the first and second semesters. Once students have grasped the fundamental sciences in the initial semesters…they can choose a field of specialization in the following semesters, such as telecommunication, electrical power, or computer* *science. Consequently, this curriculum revision aims to prepare students with knowledge and skills aligned with the trends and requirements of the industry 4.0 era*" (P2F1).

The goal of the curriculum in the current developing technological transformation is to prepare engineering graduates to face challenges and opportunities in the digital era. The curriculum focuses on the development of digital skills, technological literacy, and a deep understanding of emerging technologies. Currently, technology has also transformed into the realm of renewable energy issues. In addition to being known as the term 'Industry 4.0,' a recently prominent concept has emerged, referred to as 'Society 5.0.' The term 'Industry 4.0' was advocated by Germany, while 'Society 5.0' was championed by Japan. The implementation of Industry 4.0 technology enables the creation of intelligent and data-driven networks that swiftly and precisely connect systems within a connected environment.

"*Industry 4.0 cannot stand alone; it must be multi-sectoral. Its distinctive feature is how to integrate hardware and software. How to bridge it, that is what characterizes Industry 4.0 today. For example, with the existence of programming and microcontrollers that used to only exist in electrical engineering, but now they have become multi-disciplinary*" (P5F2).

The discussion held by the speakers regarding the curriculum objectives of Higher Education in Electrical Engineering, in response to the demands of Industry 4.0, involves opinions that support and reinforce the viewpoints of other speakers. They feel that curriculum objectives need to be clear and aligned with industry needs. As a result, engineering knowledge must be acquired in the early semesters, allowing for further specialization in subsequent semesters. Specializations are tailored according to individual student preferences.

"*The Electrical Engineering curriculum has been revised, constructed based on approximately 20% of the total credit hours in the early semesters, rooted in mathematics and fundamental sciences*" (P3F1).

Despite agreeing with the curriculum changes in response to Industry 4.0 demands, one participant in the discussion emphasized the importance of maintaining fundamental foundations within the curriculum.

"*Institutions must remain grounded in fundamentals... so what students need to master is based on the reference provided by accrediting bodies. Therefore, one should not get ensnared by courses that can be self-learned even though they support Industry 4.0*" (P8F2).

Stakeholder participants feel that curriculum changes have broadened perspectives and ideas regarding Industry 4.0 needs. Through these changes, they believe that the curriculum can become more relevant and responsive to the demands and technological advancements of the industry 4.0 era.

"*The Electrical Engineering curriculum that we updated... and uhm... yesterday was a bit dizzy about Emancipated Learning, Emancipated Campus because maybe there are 20 credits, of which 4 semesters go to industry, this must then be adjusted again...*" (P2F1).

One of the stakeholder participants in the discussion mentioned that the ‘Emancipated Learning, Emancipated Campus' curriculum still creates confusion in its implementation due to the inclusion of conversion process into more specific competency-based courses. This conversion process requires a deep understanding of the desired competencies, the integration of appropriate materials, and the use of suitable evaluation methods to ensure the achievement of these competencies. To address the confusion regarding the conversion of industrial internship outcomes and to maintain the quality of students' electrical competencies, universities in Indonesia offer general courses adjusted with industrial internship principles as a balanced solution.

“*As a middle way…. if students want to maintain the quality of electrical competence which may not be converted into courses in study programs….my campus provides generic courses that are in accordance with the principles of industrial apprenticeship. But in practice... it still has to be evaluated by a team of supporting lecturers*” (P9F2).

Despite its challenges, the implementation of the 'Emancipated Learning, Emancipated Campus’ curriculum has the potential to provide more tangible and relevant benefits in preparing students to face the ever-evolving demands of the job market. This is because students will have the opportunity to directly practice communication skills, hard work, teamwork, and attitudes in the industry.

“*I agree that… if students are introduced to the 'Emancipated Learning, Emancipated Campus’ curriculum... that is, students are introduced to other fields which will provide other experiences to students... so that they can feel a different atmosphere in the industry. What is the reality like…in order to be able to practice what is taught in class that soft skills are important …*” (P1F1).

Furthermore, the curriculum change also enhances the focus on practical and industry-relevant skills. The updated curriculum will provide students with the opportunity to develop skills such as problem-solving, creativity, collaboration, and communication, which are crucial in an increasingly interconnected and transforming work environment.

“*Of course, all of these changes are correlated with Industry 4.0 and Society 5.0, leading to a shift towards basic science and engineering. The goal of curriculum transformation is to hone students' skills further*.” (P7F2).

One of the speakers also added the viewpoint that curriculum adjustments should align with industry needs, one of which is by collaborating.

“*Collaborating with the industry can involve sending students or lecturers for internships in industrial settings, thus enabling them to understand industry requirements better* (P3F1).

The curriculum adjustment was also highlighted by another resource persons.

“*The courses are oriented towards basic science and engineering, proportionally directed towards emerging issues such as renewable energy, machine learning, AI, cloud computing, information technology, and others. This specialization is intended to refine their expertise. Their skills and competencies are honed to support their capabilities*” (P7F2).

The joint discussion conducted by resource persons regarding the objectives of the Higher Education Electrical Engineering curriculum in responding to the demands of Industry 4.0 revealed a number of aligned and mutually reinforcing perspectives. The stakeholder participants in the discussion felt that the curriculum objectives should be clearly defined and directed towards meeting relevant industry needs. Therefore, it is crucial for engineering knowledge to be imparted in the early stages of education, so that it can be further specialized in subsequent semesters. The determination of specializations is also tailored to students' choices to provide flexibility in developing interests and skills in accordance with individual preferences.

Overall, the focus group stakeholder participants agreed that curriculum changes have had a positive impact on broadening insights and ideas towards the demands of Industry 4.0. By adopting a more progressive and relevant learning approach, it is expected that graduates will be better prepared to face the competition in an increasingly dynamic industry.

3.2 Supportive Learning Materials for Industry 4.0

The preparation of electrical engineering students to meet the evolving demands of the industry requires adjustments to the learning materials. The adaptation of electrical engineering courses in the industry 4.0 era involves the integration of digital technologies and the latest innovations, focusing on concepts and applications such as the Internet of Things (IoT), Artificial Intelligence (AI), cyber-physical systems, big data analytics, and wireless technologies. Additionally, there will be an emphasis on understanding and applying intelligent technologies in power systems, industrial automation, and smart control, which will constitute an integral part of the coursework. As a result, students will possess relevant skills and are expected to become professionals ready to face the challenges of the industry 4.0 era.

"*Technology and digitization have become… a necessity and a breath in the implementation of every program that supports the learning and curriculum of Electrical Engineering*" (P4F1).

Another participant in the discussion stated that the curriculum change has accommodated learning about advanced technologies such as Artificial Intelligence, the Internet of Things (IoT), big data, and various other digital technologies. This enables students to comprehend and adapt to the significant changes occurring in the industrial world.

"*So... all the fundamentals related to Industry 4.0 have indeed been incorporated across all disciplines. It's not just limited to data processing skills, Artificial Intelligence, or IoT, and it's not exclusive to the Computer Engineering and Telecommunication programs. Instead, it's accessible to all students from various programs*" (P4F1).

The advancement of technology has not only impacted the education and industrial sectors but has also reached other domains, including healthcare, social, economics, and public services.

"*With the emergence of technology in the era of the 4th industrial revolution... it greatly benefits various fields, for example, in healthcare. Given the high cost of hardware or equipment in the healthcare field... for instance, translating radiology results, technology such as machine learning and big data have significantly aided the process. These technologies provide precise and more accurate readings*." (P6F2).

The development of technology brings numerous advantages that extend across various aspects of life. In industries, technology has enhanced production efficiency and product innovation, leading to economic growth aimed at improving the quality of people's lives.

"*Another technology emerging in the industrial era pertains to public services, such as in the field of goods delivery. This means... everything has transitioned from manual activities to systematic processes*" (P6F2).

One of the discussion stakeholder participants formulated curriculum adjustment by incorporating several material points related to sensors, embedded systems, and control linked to current issues such as renewable energy. This adjustment is designed to synergize with other study programs, for instance, mechanical engineering and civil engineering. Through these adaptations, new courses are introduced, and some existing courses are modified. For example, elective courses are now integrated into foundational courses, and vice versa. Furthermore, the participant emphasized the importance of including a capstone design course and understanding design thinking concepts within the context of digital business processes.

"…. there are new courses introduced and some existing courses are adjusted. For instance, what used to be part of elective courses is now integrated into foundational courses. And vice versa. Additionally, this approach prepares students for a future entrepreneurial mindset. With the incorporation of a capstone design course and the study of design thinking within digital business processes" (P5F2).

In line with the above, the Head of the Electrical Engineering Study Program from another university added:

"...and... because there are several courses that then need to be aligned with industry, they must be synchronized with which courses..." (P2F1).

Supportive courses for Industry 4.0 must be provided to electrical engineering students.

"*In interpreting the needs of Industry 4.0, the Electrical Engineering Program offers elective courses totalling 24 credit hours, encompassing AI, Machine Learning, Data Mining, and others*" (P8F2).

In the context of the technical implementation of the discussion, students receive lessons and then identify problems that can be solved through the application of knowledge and Industry 4.0 technologies directed towards industries. However, during the discussion, one participant provided their own perspective regarding their capstone design.

"*This learning process yields a work known as the mini capstone design. In its technical aspect, students are provided with materials, and then they identify a problem that can be solved using fundamental knowledge and utilizing Industry 4.0 technologies that haven't yet been applied in a business context*." (P2F8).

A resource person expressed their viewpoint as stated above because the program at their institution has stipulated that laboratory practices must be conducted independently. This implies that the organization of laboratories is not directly related to specific courses. The goal is to ensure that laboratories can proceed alongside the same number of meetings and align with the material taught during lectures.

The capstone design course focuses on the concept of design thinking within the context of digital business processes and involves group tasks to complete a simple capstone project that includes surveying potential users, capstone design, and customer validation. Students can gain experience in designing products and working in teams, indirectly fostering a business-oriented mindset. This curriculum change is considered highly significant and thus can accommodate emerging Industry 4.0-related issues.

"*Capstone design becomes a hallmark of electrical engineering that teaches teamwork, collaborative problem-solving, presenting, and communicating the results*" (P3F1).

Another participant added:

"*With the inclusion of the capstone design course... and also studying design thinking within digital business processes, it will be beneficial for the future"* (P5F2).

The discussion stakeholder participants also noted that curriculum changes have spurred the implementation of more innovative and project-oriented teaching methods, simulations, and real-life interaction with the industry. This enables students to experience real-world situations and gain practical insights into the challenges and opportunities posed by Industry 4.0.

3.3 Challenges and Constraints in Implementing the Higher Education Curriculum for Electrical Engineering in the Industry 4.0 Era

The implementation of the Higher Education Curriculum for Electrical Engineering in the Industry 4.0 era requires support from various aspects. One of these aspects is facilities. Adequate facilities for higher education especially in electrical engineering program are essential, as they play a pivotal role in preparing students to become competent professionals ready to face challenges in the industry. Complete and modern electrical engineering laboratories allow students to learn and practice using the latest equipment and technology. However, comprehensive equipment entails significant costs. Facility limitations encompass a lack of fully equipped and modern laboratories for experiments and practical work, a scarcity of up-to-date software and hardware for research and development, and inadequate classroom space and learning facilities. Additionally, limited budgets can hinder the renewal or expansion of existing facilities. Despite confronting these challenges, collaborative and innovative efforts among educational programs and collaboration between universities and industries have been undertaken.

".... right from the beginning, collaboration has been necessary, as the perspective on facilities is still minimal and incomplete. Another constraint is budgetary issues" (P4F1).

Thorough planning in human resource management also needs enhancement:

"*To develop faculty competencies... it's essential to conduct technical faculty training... aimed at providing teaching skills, delivering course content effectively, and ensuring the successful conveyance of engineering topics*…" (P3F1).

Several discussion stakeholder participants argue that facilities functioning as research and innovation hubs will assist students in honing their research abilities and contribution to relevant scientific discoveries. Technologically-equipped campus facilities also support distance learning, artificial intelligence development, and the utilization of cutting-edge technology in the learning process. With adequate facilities, higher education in electrical engineering can produce quality graduates who are prepared to adapt to industry advancements and contribute to creating innovative solutions beneficial to society and the industrial world.

One of the resource persons mentioned that their university has made various efforts to provide adequate facilities for their students. They have collaborated with industries that offer specific assistance to students, ensuring that students acquire industrial basics upon graduation.

"*Regarding facilities, our study program has interdisciplinary laboratories that collaborate with private companies... Indosat and Telkomsel. Industries provide special assistance in the form of training, workshops, and competency certification exams so that when students graduate, they already possess industrial basics*" (P3F1).

In connection with the effort to provide specialized experiences for students even with limited university facilities, it cannot be denied that universities still need to strive to find suitable industrial partners aligned with the students' fields of expertise.

"*However,... that the industry should be filtered to ensure its relevance to the field of expertise... namely the field of electrical engineering*" (P1F1).

The opinion of one of the discussion participants indeed needs to be considered. Filtering collaborations with industries to align with the field of electrical engineering offers significant benefits. By conducting this filtration process, the collaboration between academia and industry can generate projects that are more relevant and highly competitive in technology. Through appropriate collaboration, access to industrial resources, such as production facilities, equipment, and practical knowledge not available in academic settings, can be obtained. Furthermore, collaboration filtration can ensure alignment between academic and industrial goals, allowing research outcomes and technological innovations to be implemented more effectively in the industrial world, driving technological advancements in the field of electrical engineering.

Furthermore, industrial internship evaluation is highly essential to ensure the alignment with students' interests. Through evaluations, it can be examined to what extent this internship program encompasses aspects that are of interests to the students and how well the needs of the industry can be met.

"*…that industrial internships also need to be evaluated to match their interests.…*" (P9F2).

Evaluation provides an opportunity for stakeholders to assess the effectiveness of the industrial internship program, identify potential improvements, and enhance the quality of the student experience. With ongoing evaluation, industrial internships can become beneficial and relevant experiences that enable students to develop skills and knowledge aligned with their interests and career objectives.

We explored the perspectives of stakeholders participating in the discussion to inform the implementation of the electrical engineering curriculum in the industry 4.0 era. We found that the implementation of the electrical engineering curriculum in the industry 4.0 era has undergone adjustments to meet challenges and contemporary industry needs. Essentially, every year there is an evaluation, and nearly all study programs include courses on AI, data science, machine learning, robotics, and cloud computing. These courses are not limited to computer science alone; almost all study programs introduce Industry 4.0 technologies as they represent the hallmark competencies of Industry 4.0. However, the credit hour allocation is not yet optimal. There are also differing opinions regarding the allocation of credit hours in the curriculum. Sometimes practical courses cannot be converted into credit hours. This poses one of the challenges in adapting the electrical engineering curriculum to the industry 4.0 revolution.

Our findings have implications for how students gain industrial experience. Industrial experience for students can be obtained through various methods to prepare for the working world. One way is through internships or work placements in industries relevant to their field of study. Furthermore, student participation in collaborative projects with industries initiated by universities also offers them the opportunity to work alongside industry practitioners and tackle real challenges. Meanwhile, seminars, workshops, or professional development events at universities provide insights into the industry and career opportunities. These industrial experiences not only help expand professional networks but also aid students in understanding the work environment, developing practical skills, and grasping the demands of the job market. All these experiences play a crucial role in providing a tangible career perspective and assisting students in becoming more competent prospective professionals ready to face real industry challenges.

Moreover, the cost of advanced equipment and infrastructure to support this curriculum can be a challenge for some universities. Nevertheless, with continuous efforts to enhance active collaboration between academia and industry, these obstacles are anticipated to be overcome, enabling graduates to be prepared for changes and industry demands in the industry 4.0 era.

The implementation of the discussion can be categorized as smooth, as it did not encounter significant obstacles. Each participant in the discussion actively expressed their opinions and, at times, complemented statements from other stakeholder participants. Overlapping or interrupting voices never occurred as we, the moderators, carefully orchestrated the flow of the discussion to prevent overlaps and ensure a harmonious and focused atmosphere.

During the analysis process, we found a variety of opinions from the speakers as recurring evidence that supports our research theme. Some stakeholder participants engaged in the forum and contributed by sharing their insights on the implementation of the higher education curriculum in electrical engineering during the industry 4.0 revolution. The contributions of stakeholders are crucial as they participate in curriculum development to support various targeted policies. Despite the fact that we did not involve all heads of electrical engineering study programs in public legal entity higher education institutions, the majority of stakeholders remained engaged in our effort to examine.

4. Conclusions

Collaborative discussions on the implementation of electrical engineering curriculum in the industry 4.0 era have been presented here. The engagement of higher education institutions, industries, and policy stakeholders is crucial to ensuring the curriculum's relevance to the latest technological developments, industry needs, and future job market demands. By collaborating, they can design a curriculum that integrates cutting-edge technologies and focuses on mastering practical skills that align with Industry 4.0 requirements. Furthermore, the involvement of all parties also supports the adoption of technology in teaching and research processes, facilitates knowledge and technology transfer, and strengthens graduate competencies to face global challenges. This will ensure that graduates of the industry 4.0 electrical engineering era are ready and capable of significantly contributing to the ongoing industrial revolution and advancing technological progress in Indonesia.

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