Blended Learning Based Project In Electronics Engineering Education Courses: A Learning Innovation after the Covid-19 Pandemic

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Muhammad Anwar[1], Hendra Hidayat[1(✉)], Ika Puspa Yulistiowarno[1], Khairi Budayawan[1], Zulwisli[1], Obaze Agbonluae Osumah[2], Zadrian Ardi[1]
[1]Universitas Negeri Padang, Padang, Indonesia
[2]Ambrose Alli University, Ekpoma, Nigeria
hendra.hidayat@ft.unp.ac.id

Abstract—Engineering education is an important part of preparing quality graduates for the challenges of the Covid-19 and post-pandemic conditions, and electronics engineering education is no exception. Blended learning-based projects as an alternative to innovative learning at this time. This study aims to explore and explain the application of blended learning-based projects in electronics engineering education courses. The research method used is a project-based product design and development carried out by blended learning. We conduct our project activities in higher education special students from Electronic Engineering Education that take part in the learning of this project. Students who participate are only limited to small groups to avoid the impact of the Covid-19 pandemic, in 1 small group consisting of 3–5 people and there is 1 group leader who manages the work, while other members are supportive and help complete joint projects. The results of this study show the ability of students to work by implementing project-based learning in producing products, namely Exhaust Fan products based on Electrostatic Precipitator (ESP) as a form of a mini prototype that can be used for small household scale industries. The ability of students to work on product manufacturing by applying the principles of project-based learning in the category already has the ability to, skilled and thoroughly working on the project that was planned until it succeeded in becoming a product prototype which was carried out in a project-based blended learning.

Keywords—blended learning, project, electrostatic precipitator, electronics engineering education, learning innovation

1 Introduction

Engineering education in recent years has experienced major obstacles in pedagogy, teaching and learning, due to the influence of the Covid-19 pandemic that has hit the whole world [1, 2]. Whereas engineering education has an important role in supplying professionals, especially in higher education [3]. Learning during the Covid-19 pandemic uses various online platforms to support learning, but sometimes it is also less than optimal [4]. Online learning that is carried out must be supported by optimal facilities both in terms of learning facilities, learning readiness, digital literacy and good internet quality [5, 6]. Based on current conditions, face-to-face learning can already be carried out even though it has to implement very strict Covid-19 controls [7]. Even so, online learning is still being implemented, because it is felt to be effective and efficient, especially in higher education [8, 9].

Electronic engineering education has a major role in preparing graduates who are competent in the job market [10]. The implementation of online learning is still not optimal, because of the weak control in learning activities and the competency targets to be achieved are still weak [11]. Learning that is done face-to-face and combined with online learning is an alternative that fits the characteristics of pedagogy in engineering education [12], we know this mixed learning alternative as blended learning [13]. The application of blended learning is a solution to learning in engineering education, especially if the learning carried out demands to produce projects. In project implementation, it is known as project-based learning, was originally used in professional training in medicine and is also used in engineering [14]. Traditionally, project-based learning has been used in engineering programmers, called final year projects. Project-based learning has become a strategy for teaching design in many engineering programs. So that blended learning based projects in engineering education is an alternative learning during and after the Covid-19 pandemic [15]–[17].

Electronic engineering education in its courses always prepares graduates who have competence in the field of electronics [18], one of the knowledge of these competencies is the principle of electrostatic precipitator in electronic engineering courses. Electrostatic precipitator (ESP) is a technology to capture ash from the combustion process by giving an electric charge to the dust particles in the smoke [19]. ESP is a development technology from static electricity. ESP is generally used in air filter equipment, to produce clean air that is safe for health [20]. Electrostatic Precipitator technology is also widely used in education [21]. In the field of environmental science and resource use, ESP is also used as a medium for smelting and combustion processes as well as new applications carried out in experimental studies where ESP can remove pollutants, gases, and peculiar odors from the smelting process [22, 23].

In the industrial world, ESP is very widely used, therefore ESP has a great relationship with the field of Electronics [24]. The ESP system also consists of several electronic circuits. Thus, many developments and innovations can be learned again by students majoring in electronics in Higher Education. Electrostatic Precipitators can be used in teaching and learning in engineering education, especially in electronics engineering education. The engineering education learning carried out aims to improve competence and is oriented directly to face to face learning. Learning by explaining ESP principles in everyday life provides a more meaningful and memorable and memorable experience and learning for students.

Blended learning based projects, which is applied in electronics engineering education courses as a solution to improve the competence of electronic engineering education students and at the same time provide a meaningful learning experience in higher education [25]. Project creation can be done face to face and materials and controls can be done online [26]. An electronics project with the principle of electrostatic precipitator in electronics engineering courses such as air pollution handling air pollution in food industry activities that need serious handling. Through this problem, an ESP-based Exhaust Fan project can be designed that is environmentally friendly and User Friendly. The result of the Exhaust Fan with the ESP concept is a form of implementation in the field of electronics in everyday life. So the purpose of this paper is to discuss the application of blended learning based projects in electronics engineering education courses.

2 Research methods

2.1 Participants

We conduct our project activities at Universitas Negeri Padang (Indonesia) special students "Electronic Engineering Education" take part in the learning of this project. The students who participated in this study were from 20 to 22 years old. Students who participate are only limited to small groups to avoid the impact of the Covid-19 pandemic, in 1 small group consisting of 3–5 people and there is 1 group leader who manages the work, while other members are supportive and help complete joint projects.

2.2 Methods of blended learning

In blended learning in learning that can be done with various combinations of available facilities [27], as follows:

1. Learning management system (Moodle, Edmodo).
2. Tools for creating and publishing training content and objects (test designer).
3. Tools for communication and feedback (Skype, Google Chat).
4. Tools for collaboration (Google Docs).
5. Tools to create a community (Facebook social network).
6. Tool for planning educational activities (electronic journal).

2.3 Project stages

While the implementation of project activities is carried out using a project-based product design and development method [28], to make an Exhaust Fan in the home industry using the Electrostatic Precipitator (ESP) Principle. There are six phases in the product manufacturing process, as follows:

Planning. Planning in this method is also referred to as "phase zero" because planning is the initial process before the actual product development process. This phase begins with identifying opportunities and reviewing technological developments and market objectives. In the planning process there are 2 activities carried out starting from opportunity identification to product planning. An opportunity is a picture of a product in the form of an embryo before the product is finished and can be marketed to the public. Opportunities can be obtained from the needs needed by society and the environment as well as new technologies found. At the earliest stage of product development, the product will be faced with uncertainty regarding the sustainability of a product on the market, so that opportunities can be considered as hypotheses about how a product can be created and accepted by society. Some opportunities could end up being a new product while others could end up being just a plan and no further development being carried out. The potential for home industries in developing countries such as Indonesia is very high, so the opportunity to use smoke filter chimneys using the electrostatic precipitator principle is quite large. The output of this planning stage is in the form of product specifications to be made. Specifications of Chimney Filters In Home Industry Using Electrostatic Precipitator (ESP) Principles are as follows: 1). Using a 12V, 10A (120W) power supply; 2). The casing uses a zinc plate.39; 3). Filter measuring $60 \times 60 \times 60$ cm; 4). Using AC blower for smoke suction; 5). Using MQ-2 sensor for Output Quality Detector; 6). Using a 16×2 LCD to display the MQ-2 sensor readings.

Concept development. In the Concept Development stage, it can be interpreted as a development concept, community needs are the main thing that must be identified, product concepts that already exist and have been evaluated which will later produce more concepts to be selected for development and further tested. What is meant by concept is a description of the form, function and features of a product accompanied by product specifications and analysis. The manufacture of chimneys that are filtered with the principle of an electrostatic precipitator is different from ordinary chimneys, because the smoke released will be cleaner than ordinary chimneys. Initially the smoke from the furnace is sucked into the chimney using a blower then the smoke passes through a filter that has been given the ESP principle. The way the filter works, which has been given the ESP principle, is that the smoke that passes through the filter will be given a negative charge (electrons) by a voltage multiplier circuit, so that the smoke has a greater electron charge than before, causing the smoke particles to be attracted to the excess electrons in the filter. where the filter where the smoke particles attach is connected to the positive pole of the voltage multiplier circuit. Because the smoke particles have stuck to the filter so that the air coming out of the chimney will be clean and free of smoke particles. To prove the cleanliness of the air it emits, this chimney is equipped with a smoke detection sensor that displays the quality of the output from the chimney through the LCD.

System-level design. In the System-Level Design phase, it includes the architecture, components and initial design of the product to be made. Initial plans for the production system and final assembly are usually determined during this phase as well. Next, the product plan workflow starts by turning on the tool and then the power supply will channel 12V DC electricity to the flyback driver then it is flowed to the flyback and flowed to the filter. The Power Supply also supplies electricity to the Output quality detector. After all systems are on, the smoke will pass through the filter and smoke particles will stick to the collection electrode. Then the filtered output will be checked for quality by the MQ-2 sensor and the results will be displayed on the LCD screen. Furthermore, the operation of this chimney filter begins by turning on the tool then the blower will immediately activate so that the smoke will be sucked in. After the blower is on, the power supply will channel 12V DC electricity to the DC to AC Inverter, after being converted back into AC voltage, the voltage will be folded to 10,000V and flowed to the filter. The Power Supply also supplies electricity to the Output quality detector. After all systems are on, the smoke sucked by the blower will pass through the filter and smoke particles will stick to the collection electrode. Then the filtered output will be checked for quality by the MQ-2 sensor and the results will be displayed on the LCD screen. The smoke sucked in by the blower will pass through the filter and the smoke particles will stick to the collection electrode. Then the filtered output will be checked for quality by the MQ-2 sensor and the results will be displayed on the LCD screen.

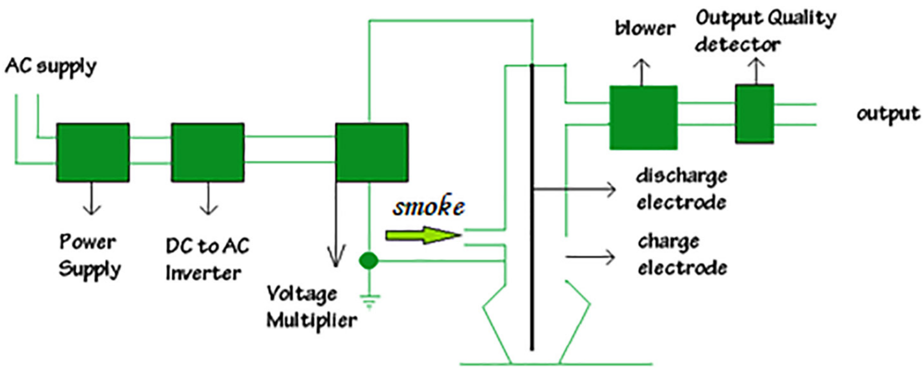

Fig. 1. Basic diagram of an electrostatic precipitator

Block diagram is a system diagram in which the main part or function is represented by blocks connected by lines that serve to connect each block. This tool has six main parts with different functions, namely power supply, DC to AC Inverter, Voltage Multiplier, Discharge electrode, Collector electrode, Output quality detector. The following is a tool design which is a final description of the product to be made.

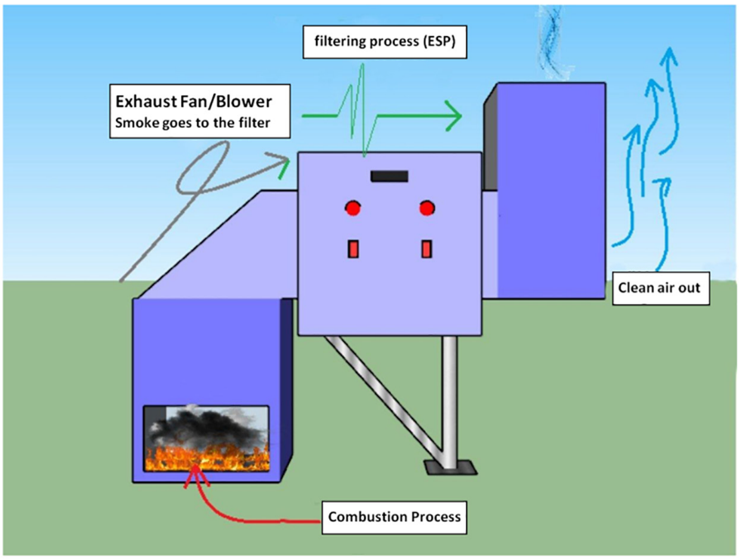

Fig. 2. Product design

In the design of the device above, the exhaust fan sucks smoke from the combustion products that enters the ESP filtering chamber and then comes out to produce clean air. This ESP filter uses a zinc plate so it has a light weight and is rust resistant.

Details design. The Detail Design stage includes the complete specification of tools, materials and special parts in the product. This stage designs each part that will be made in the production system. The output of this phase is control documentation for the product, drawings or computer files describing the geometry of each part and its production tools, specifications for purchased parts, and a process plan for assembling the product. Three important issues that should be considered throughout the product development process, but resolved in the detail design stage, are material selection, manufacturing costs, and robust performance. Design details include: 1) Flyback Transformer, designed to work with input frequencies of 15–150 KHz, so that in order to run the flyback transformer properly, a driver is needed that can generate square waves with a frequency of 15–150 KHz. This flyback driver uses ic 555 as a square wave generator and is amplified using a transistor connected to a mosfet., and 2) Output quality detector, this circuit is used as a detector of air quality resulting from the smoke filter chimney. The sensor used in this circuit is the MQ-2 sensor. Gas Sensor (MQ2) is a sensor that is useful for detecting gas leaks in both homes and industries. This sensor is perfect for detecting H_2, LPG, CH_4, CO, Alcohol, Smoke or Propane. Due to its high sensitivity and fast response time, measurements can be made quickly. The sensitivity of the 46 sensor can be adjusted with a potentiometer. The way this tool works is when there is smoke or air density increases, the resistance on the MQ2 sensor will decrease and current will flow to the Arduino. From Arduino, the command is given to the LCD to change the notification text that is displayed, besides the LCD the command is also given to the red led and buzzer to light up as a danger indicator. Then the fan will spin to suck up the smoke in the room until the air density in the room is clean again. The MQ-2 sensor has 2 input voltages, namely VH and VC. VH is used for the voltage on the internal heater and Vc is the source voltage and has an output that produces a voltage in the form of an analog voltage. The following is the configuration of the MQ-S sensor: 1). Pin 1 is an internal heater connected to ground; 2). Pin 2 is the source voltage (VC) where Vc < 24 VDC; 3). Pin 3 (VH) is used for the voltage on the internal heater where VH = 5VDC; 4). Pin 4 is an output that will produce an analog voltage.

Testing and refinement. The Testing and Refinement phase involves construction and pre-product evaluation. Usually this part starts from making a prototype using the exact same materials as the materials that will be used in the finished product, but not necessarily with the actual process that will be used in production. The prototype will be tested to determine whether the product functions as designed and meets the requirements. It aims to answer questions about performance and identify the engineering changes required for the final product. The following are three important things in prototyping: First, determining when the tools and materials will be ready to be assembled; Second, determine when the prototype will first be tested; Third, determine when is the right time to complete the test and produce the final product. After this stage has been completed and has been evaluated, there will be improvements from deficiencies in the product, so that if it has become a final product and is marketed it will be in accordance with the wishes and needs of the community.

Production ramp-up. At the Production Ramp-Up stage, this product is made using the intended production system. The purpose of this Production Ramp-Up is to train the workforce and to resolve any remaining problems in the production process. Products produced during the Production Ramp-Up will be supplied to customers in need and carefully evaluated to identify any remaining shortfalls. The transition from Production Ramp-Up to ongoing production is usually gradual. At some point in this transition, the product was launched and made available for wide distribution. A post-launch project review can occur immediately after launch. This review includes an assessment of the project from a commercial and engineering perspective and is intended to identify ways to improve the development process for future projects.

The assessment of quantitative to qualitative data from the results of the project competency evaluation of students' abilities refers to Table 1 below.

Table 1. Converting quantitative data to qualitative data

Average Score	Classification of Student Project Competency Abilities
64 – 90	Ability Can, skilled and complete
36 – 63	Can with Help and direction
10 – 35	Less and can't

3 Results and discussion

The resulting project follows the steps and stages described in the previous research method section, at this stage the results of student project work in producing Electrostatic Precipitator (ESP)-based Exhaust Fan products are presented, along with the results of the project work.

Fig. 3. Chimney construction

Fig. 4. Filter construction

Fig. 5. Flyback driver series

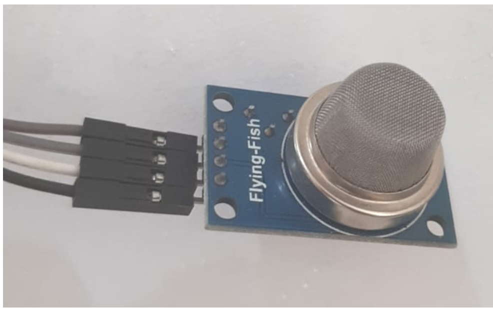

Fig. 6. MQ2 sensors

This smoke filter chimney is made with a length of 150 cm, a width of 50 cm, a height of 1 meter on the left and 130 cm on the right as shown in Figure 3. The framework for forming the hardcase of this chimney filter uses iron holo and part of the walls uses GRC board and some others. using zinc plate. As for the filter section measuring 50 × 30 cm, which contains an arrangement of zinc plates and the outside is protected by acrylic as shown in Figure 4. The flyback driver circuit is made based on the circuit scheme that has been made previously, the realization of the flyback driver is shown in Figure 5. Next Output Quality The detector is made according to the designed schematic, as shown in Figure 6 MQ2 gas sensor.

3.1 Circuit test results

The test results for the chimney filter circuit are shown in Table 2 below:

Table 2. Circuit test

No	Measuring Point	Score Ideal	Score Measurable	Information
1	Power Supply	11 V	11 V	In accordance
2	VGS	5 V	5 V	In accordance
3	V Thres	5V	5 V	In accordance
4	V Trig	5 V	5 V	In accordance

Based on the results in Table 2, it can be concluded that the results of each measurement made at the measuring point are in accordance with the ideal value that has been set at each measuring point. Where the ideal value of each measuring point is obtained from the provisions based on the theory relevant to the circuit and the component datasheet used.

3.2 Validity and reliability results

The results of the chimney filter validation are shown in Table 3 below:

Table 3. Validation results

No	Test Aspect	Looks like Smoke	Output quality detector results	Information
1.	1 sheet	Invisible	35	Well
2.	2 sheets	Invisible	47	Well
3.	3 sheets	Invisible	52	Currently
4.	4 sheets	Thin	60	Currently
5.	5 sheets	Thin	71	Currently

So based on the results obtained from Table 3, it can be concluded that this smoke filter chimney has been running according to what has been desired and the output value of the output quality detector has been adjusted to the value of the National Air Pollutant Standard Index.

3.3 Evaluation of student project competency ability

The project that has been created after testing and measurement, then it is necessary to evaluate the project's competence. Project competence is expressed in personal and professional development as a result of project activities at the procedural and operational levels. Project competencies include cognitive, operational, communicative, and reflective components. The structure and project competency indicators of student abilities [27], are listed in Table 4 below:

Table 4. Competency project indicators

Component	Characteristic
Cognitive component	a. Information analysis and problem formulation b. Understand the subject of the project c. Determining the objectives of project activities d. Planning project activities, and product design.
Operational components	a. Ability to organize project activities. b. Ability to monitor, and evaluate project activities. c. Ability to apply knowledge in project activities.
Communicative component	Communicative and collaborative skills of project team members.
Reflexive component	Ability to evaluate and analyze the results of project activities

The purpose of evaluating student competence in implementing project work is to see the process of activity and teamwork that occurs during the work process [29, 30].

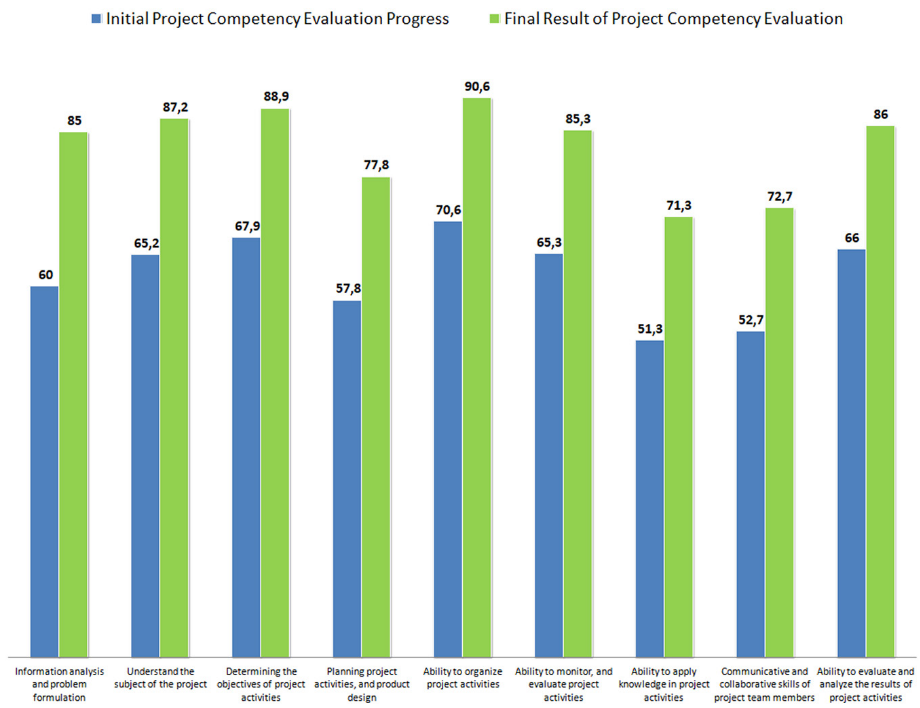

Fig. 7. Evaluation of student project competencies

The results shown in Figure 7 are student project competency evaluations carried out in two stages, namely, initial project competency evaluation progress and final result of project competency evaluation. In the initial project competency evaluation stage, the average student's ability to carry out project work was obtained with a score of 62 with the meaning that students were still categorized as able with the assistance and direction of the lecturer in project work. In the initial project competency evaluation stage, the lowest score was 51.3 in the Ability to apply knowledge in project activities aspect, while the highest score was 70.6 in the Ability to organize project activities aspect. This initial implementation provides space and opportunity for mutual discussion, especially sharing knowledge with lecturers and complementing and sharing knowledge.

Furthermore, in the final stage of the result of the competency evaluation project, it seems that improvements have begun, although not significant, namely the average ability of students in carrying out project work with a score of 83 with the meaning that students are still categorized as capable, skilled and complete in project work. In the final stage, the result of project competency evaluation with the lowest score is 71.3 in the Ability to apply knowledge in project activities aspect, while the highest score is 90.6 in the Ability to organize project activities aspect. The final evaluation shows that students have understood the work process of making projects and the resulting projects are of quality according to the measurement results, namely the results of each measurement taken at the measuring point are in accordance with the ideal value that has been set at each measuring point, the ideal value of each measuring point is obtained from the determination based on the theory relevant to the circuit and the component datasheet. Meanwhile, the output quality detector is of good and medium quality. All these processes are carried out by applying project-based learning combined with blended learning [31, 32].

Project-based learning in engineering education has become one of the programs and methods to increase student involvement and learning activities [33]. Project-based learning is no exception in electronics engineering education, it really helps students to learn actively so as to provide a good learning experience and indirectly have an impact on improving and mastering student competencies [34]. Project learning is strongly supported by various technologies, features and applications that support blended learning [35], such as Google Docs, Learning Management System, and video meeting applications. The blended learning pattern applied is supportive to improve the effectiveness and efficiency of learning. The combination of learning models carried out is estimated to be face-to-face implementation is 75% and online implementation is estimated to be 25%. The strategy of organizing and delivering teaching that has an important role in the learning process with blended learning [36, 37].

The implementation of online dominant learning has an impact on the variation in students' understanding of the information and knowledge conveyed by lecturers [38, 39]. So that the teaching organization strategy, teaching delivery, and teaching quality with face-to-face learning in the classroom are more optimized and can take advantage of available technological developments, which has an impact on the emergence of desire and interest in learning. The implementation of blended learning is an internet-based model as a learning resource [40, 41]. The advantage of this method is that learning is not centered on the teacher so that student creativity can develop, besides that it will also create an effective learning process, so that it can increase student interest and learning outcomes. The use of technology-based media allows learning to be done more varied so that it is not boring [42]. Blended Learning can be defined as a learning process that utilizes various approaches and strategies. The approach taken can utilize a variety of media, technology and a combination of learning strategies, including the blended learning base project.

The implementation of a blended learning base project in the electronics field is an important issue, and also in the field of Electronic Engineering Education because it prepares graduates to be skilled and have competence in the electronics field who are able to compete in the job market. The development of technology in the field of electronics is growing rapidly so that it must integrate the development of electronic technology in the learning process [43, 44]. So that current engineering education learning must be product-oriented [45]–[47], commercially potential [48]–[50], and integrated with technology [51]–[54], so that graduates have the ability to compete in the job market and have good career maturity [55]. Learning in Electronic Engineering Education always prepares graduates who have competence in the field of electronics [18], one of the knowledge of these competencies is the principle of electrostatic precipitator. Electrostatic Precipitator (ESP) is an advanced technology in the air filtering process that serves to capture ash from the combustion process in the boiler or simply to filter the air in the room. Consists of an electronic circuit arrangement, which is also very environmentally friendly to filter the air. Electrostatic precipitator (ESP) in education and teaching in electronics is an effective material to increase student creativity in innovating in electronics.

4 Conclusion

This study reveals that learning in engineering education is still oriented to learning that produces products to implement the knowledge and competencies possessed by students. Learning during the Covid-19 pandemic and post-pandemic still applies an online learning system and is combined with face to face, which we know as blended learning. Project-based learning that is collaborated in blended learning is an attractive alternative for engineering education students in higher education, not least in electronics engineering education. Competence in the field of electronics today is very important to master, coupled with the integration and combination of information technology into the electronics field. Electrostatic precipitator (ESP) is one of the studies in the field of electronics that is studied in higher education, and is the main material in the implementation of project-based learning carried out by blended learning. The result of the implementation of project-based learning is an Electrostatic Precipitator (ESP)-based Exhaust Fan product as a mini prototype that can be used for small household scale industries. The ability of students to work on product manufacturing by applying the principles of project-based learning in the category of having the ability, skill and completeness to work on the planned project until it becomes a product that is implemented using blended learning and become the main material in the implementation of project-based learning which is carried out by blended learning.

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7 Authors

Muhammad Anwar, Universitas Negeri Padang, Padang, Indonesia.
Hendra Hidayat, Universitas Negeri Padang, Padang, Indonesia.
Ika Puspa Yulistiowarno, Universitas Negeri Padang, Padang, Indonesia.
Khairi Budayawan, Universitas Negeri Padang, Padang, Indonesia.
Zulwisli, Universitas Negeri Padang, Padang, Indonesia.
Obaze Agbonluae Osumah, Ambrose Alli University, Ekpoma, Nigeria.
Zadrian Ardi, Universitas Negeri Padang, Padang, Indonesia

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