

Student Difficulties and Alternative Solutions in the Embedded System (ES) Subject

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ABSTRACT ---- *The goal of this research was to identify the issues that students have in the Embedded System (ES) course, as well as possible remedies. This study was carried out during the 2019/2020 academic year at Ujung Pandang State Polytechnic. A random sample of 23 students was chosen. A questionnaire was used to collect information. The findings revealed that: media used, mastery of the content, method used, literature or teaching materials used, and how to deliver are some of the factors of student learning difficulties in ES courses. The usage of media is a major element creating student learning difficulties in ES courses, according to some of the considerations. As a result, one suggested alternative is to use the Internet of Things. The use of IoT in ES course learning can reduce student learning difficulties.*

Keywords--- Embedded System, Difficulties, Media, Internet of Things (IoT)

1. INTRODUCTION

Embedded systems (ES) are topics that are difficult to understand if only applied theoretically without a practical approach. Because this topic is related to hardware and software design integrated in one (Tukadi & Hakimah, 2017). Some studies in the field of embedded system learning include the use of lecture assignments in the form of projects conducted by researchers (Darmaliputra & Hermawan, 2014). Project assignments are temperature measurements with DS18B20 digital sensors and analog sensors, namely LM35 and thermistor 20. In addition, the development of prototype practicum modules for ES using Arduino Uno has also been developed (Budijanto et al., 2015), while ES curriculum development is very fast both hardware and software, hardware in the form of microprocessor chips to single chip microcontrollers or single-chip microcomputers and programming languages ranging from assembly languages to high-level languages (Ibrahim, 2015).

In the world of education, Embedded System (Embedded System) is one of the topics or materials that are considered quite difficult by students to understand. Therefore, needed supporting equipment in the form of software and hardware that can help facilitate the understanding of students in undergoing the process of learning embedded systems in the classroom or laboratory to conduct experiments. According to research by Junior et.al, which has been done about learning embedded systems that use open source software Fritzing and Arduino to improve students' ability to make hardware and software and integrate them into a single unit. After the learning process is done this way for 2 years, it gives positive feedback rather than learning in the conventional way (Junior et al., 2013).

Along with the development of technology, currently there are various kinds of learning media available, one of the media that has many advantages over other media, namely computers because every information in the form of text, sound, animation and images can be displayed together. Several studies have shown, if the use of interactive media can increase the mastery of concepts, learning achievement (Prastika et al., 2015), and critical thinking skills (Wiyono, 2017). The lack of use of media in learning, most Integrated Learning subjects still use print media as a source in the lecture process and at least 4-5 times use power points as a messenger (Wati, 2010). The lack of media use by lecturers is also a determining factor in the quality of lectures. The media is able to provide varied stimulation to our brain, so that our left and right brains can function optimally.

In addition, in this digital era, the development of science and technology is felt very rapidly, especially in the field of internet development. Because of that the world of education is inseparable from the development of the internet or often called the virtual world. Therefore, learning requires the availability of learning media that can be connected to the internet. Through media that uses the internet, every student or student can use the internet that is tailored to educational needs. In addition, the use of the internet which can be considered a learning medium makes it very easy for students to access information such as science, sending writings or assignments via email, and so on.

Besides students and lecturers it is easier in the learning process. The use of internet media is considered very important for the implementation of learning. With the development of the Internet of Things (IoT), the internet can also be used to achieve other goals that support the success of learning. Therefore, by utilizing the internet in carrying out both theoretical and practical learning activities, learning objectives can be achieved. One example is the use of the internet for learning activities in the Embedded Systems Course (Dias Prihatmoko, 2016).

Internet of Things is a medium for connecting between microcontrollers and the internet. Students can carry out project monitoring and see the results of development which usually use LEDs, LCDs or other actuators, displayed on websites that can be accessed from various places and at any time using a computer browser or gadget. It is hoped that with this media less innovative learning, student boredom, and learning media that do not keep up with the times can be overcome (Saputra & Hertanto, 2018). Regarding the use of IoT as a medium in learning, the results of Saputra & Hertanto's research indicate that the results of the material expert assessment based on aspects of material substance, learning design and media utilization have an average total score of 60.50 from a maximum score of 80 and are categorized as "Eligible". While the assessment by media experts based on aspects of appearance, aspects of media use, learning design, and substance of the material got an average total score of 75.50 from a maximum score of 92 and was categorized as "Very Eligible". User / student assessment responses to the Internet of Things (IoT) based learning media for microprocessor engineering in terms of substance, learning design, appearance, and media utilization, 23% of students stated "Very Eligible" and 77% of students stated "Eligible" "As media learning.

Based on the previous description of the material Embedded System (ES) and the relevance of using media in learning, particularly internet media. This study aims to provide a different approach to the development of IoT-based learning media, specifically in Embedded System (ES) courses at Ujung Pandang State Polytechnic. As a result, issues concerning the Embedded System (ES) course's challenges can be addressed. Specifically, this research aims to intends (1) to learn about several elements that contribute to learning challenges in the Embedded System (ES) course; (2) Recognize the most main factors of learning difficulties in Embedded Systems courses; and (3) viable alternative for dealing with learning issues in the Embedded System course.

1.1. Learning Difficult

Learning is a process of behavior change that is a result of the interaction between individuals and their environment to meet the needs of their lives (Widiyastuti et al., 2018). Meanwhile, learning is a process of gaining knowledge and experience, both in the form of behavioral changes and the ability to interact relatively or permanently as a result of these interaction. Learning difficulties are the emergence of symptoms in students marked by several things, among others; learning achievement is decreased or less than the value that has been set (Hikmawan, 2017). Therefore, learning difficulties can also be interpreted as a change in conditions in the learning process due to certain obstacles in achieving learning outcomes.

Blassic and Jones as quoted by say that the notion of learning difficulties shows the distance between academic achievement as expected and student achievement. More about learning difficulties, Blassic and Jones also said that the signs of students who have learning difficulties are having normal intelligence, however showing one or even some deficiencies that are important in following the learning process, both in the form of perception, memory, attention or even in motor function (Hikmawan, 2017).

The factors that can cause student learning difficulties are many or various types. However, if the cause is associated with factors that play an important role in learning, then the causes of learning difficulties can be grouped into two, namely factors originating from within students (internal factors) and also factors originating from outside students (external factors). An internal factor causing student learning difficulties can be classified into two parts, namely physiological factors and psychological factors. External factors that can affect student learning are factors that originate from outside the student, while external factors can be grouped into two groups as well, namely social factors and non-social factors (Ichsan, 2016).

1.2. Embedded System (ES)

Embedded Systems (ES) are special computer systems that are designed to perform certain tasks and are usually

embedded systems in one system (Lee, E. A., & Seshia, 2017) and (Marwedel, 2006). Embedded System (ES) is a combination of hardware and software that is embedded (embedded) in a particular device that aims to perform special functions / tasks (Heath, 2011). This system is part of the whole system consisting of mechanics and other hardware. The Embedded System (ES) field covers the mastery of hardware. Thus, the Embedded System (ES) is a digital system (electronic circuit) which is part of a larger system, which is usually not an electronic system. The word embedded indicates a part that cannot stand alone. In contrast to digital systems designed for general purposes (Jatmiko et al., 2011).

Embedded systems are usually implemented using a microcontroller, embedded systems can provide real time responses and are widely used in digital equipment, such as watches. Embedded systems are not only known in the IT world but also in the automotive and even medical world. Consumer electronics include Personal Digital Assistant (PDA), mp3 players, cellphones, video game consoles, digital cameras, DVD players, GPS receivers, and printers. Many household appliances such as microwaves, washing machines and dishwashers, which include embedded systems to provide flexibility, efficiency and features. The advanced HVAC system uses a thermostat network to control temperature more accurately and efficiently which can change with time and season.

Home automation uses cables and network cables that can be used to control lights, climate, security, audio / visual, surveillance, etc., all of which use embedded devices to monitor and control (Lee, E. A., & Seshia, 2017). In addition to the embedded systems described generally based on small computers, a new class of mini wireless devices called motes is quickly gaining popularity as an increasing field of wireless sensor networks. The wireless sensor network, JSN, uses miniaturization made possible by sophisticated IC designs for installation of complete wireless subsystems for sophisticated sensors, allowing people and companies to measure and know various things in the world (Toulson & Wilmschurst, 2017).

Some of the results of research on Embedded Systems (ES) include: (1) An application and website system on the internet is obtained by HTML and synchronized with the main server on the Arduino Severino microcontroller which is better known as a webserver in embedded systems (Zarpelão et al., 2017); (2) One solution to overcome the limitations of software-based efficiency with Embedded Systems is to implement cryptographic calculations of greedy resources on specific hardware using Application Specific Integrated Circuits (ASICs). Therefore the 'default algorithm' approach can be followed for proven performance even though it is expensive (Barua et al., 2014); (3) Significantly, direct laboratory experiments conducted here are considered cheaper for each student to run. It also covers two thirds of semester laboratory work, and inevitably gives confidence to each student by starting the complex design of each Embedded System project (Ajao et al., 2016); (4) Project-Based Learning Methods (PBL) in teaching this course have helped bridge the gap between theoretical electrical engineering education and the real world. Feedback from students illustrates the effectiveness of this method in improving students' understanding and ability in applying embedded systems design concepts to solve real-world engineering problems (Sababha et al., 2016); (5) We teach experiments embedded systems with new thinking, and design experiments accordingly. Students are required to be familiar with embedded system design methods, know about real-time operating systems, master workbench for embedded system development, be familiar with debugging methods, and understand software and hardware co-design. With this method, students can master the development of embedded systems quickly, and the effects of teaching are good (Tsasis et al., 2019); (6) Through the application and effect of practice in practical teaching for several semesters, this reform shows that the inverse class mode based on MLR has a significant effect in the experimental relationship of Embedded System design, which helps stimulate and mobilize student interest and enthusiasm at the same time to improve teaching quality (Ding et al., 2017); and (7) From the results of the above research it can be stated that embedded systems are widely applied in various kinds of monitoring and control tools, materials including microprocessor architecture, parts of microcontroller systems, input and output signals, signal processing, sensors and actuators, microcontroller programming, microcontroller applications for monitoring and control.

Embedded Systems (ES) are subjects that are quite difficult to understand if implemented only theoretically without a practical approach. Because this course discusses integrated hardware and software design into one. Some research in the field of embedded system learning includes the application of college assignments in the form of projects, practical modules, learning microcontroller architecture, Inventor applications, and circuit design that uses the main components of Arduino.

2. METHOD

This is a descriptive survey in which the facts in the field are revealed. The research was carried out throughout the 2019/2020 academic year at Ujung Pandang State Polytechnic. A total of 23 students were randomly chosen for the samples. Respondents were given a questionnaire to fill out in order to collect data. Furthermore, the data was descriptively quantitatively analyzed and qualitatively concluded. When data is described quantitatively, it is based on the tendency of existing phenomena, and when it is expressed qualitatively, it is based on a categorical narrative. As a result, we'll require a frequency distribution table as well as a percentage of each question item's response in the survey.

3. RESULT AND DISCUSSION

3.1. Difficulty studying Embedded System (ES) Subjects due to lack of mastery of material from lecturers

Based on the results of the questionnaire processing, it was obtained that in general, respondents responded positively to the mastery of the material by the lecturer. In other words, lecturers generally have mastery of material that can help students overcome obstacles in ES courses. the lecturer's mastery of the content is not a factor that causes students learning difficulties in the perspective of the ES. Nevertheless, some students perceived a lack of understanding of the topic is the reason of learning difficulties in ES courses. The results of the questionnaire can be seen in the following fig 1.

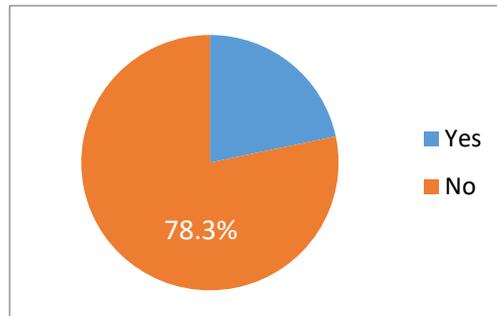


Figure1. Difficulty studying Embedded System (ES) Subjects due to lack of mastery of material from lecturers

3.2. Difficulty studying Embedded System (ES) courses due to inappropriate methods

In general, students also give positive responses to the methods used by lecturers in ES subjects. This means that in general lecturers use the right method in studying ES courses. Therefore, it can be said that the use of methods is not a cause of student learning difficulties in ES courses. Nevertheless, there are still some students giving responses that the cause of learning difficulties for ES courses is the use of inappropriate methods. The following table is a processed questionnaire about the use of teaching methods by lecturers.

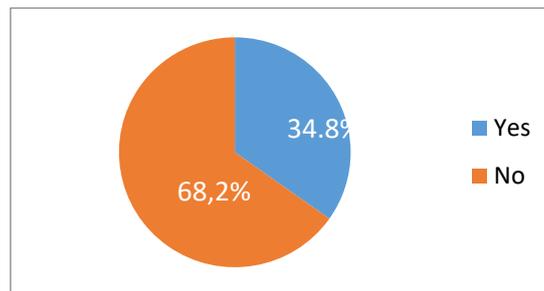


Figure 2. Difficulty studying Embedded System (ES) Subjects because the method used by the lecturer is not right

3.3. Difficulty studying Embedded System (ES) courses due to unattractive teaching methods

Positive responses were also shown by respondents about the causes of students' learning difficulties in ES courses based on the way the material was delivered. Most students gave positive responses to the way lecturers delivered in ES courses. Therefore, it can be stated that the method of delivering the material by lecturers is not the cause of students' learning difficulties in ES courses. However, there are still some students who respond that the way lecturers deliver material in ES courses is still not quite right.

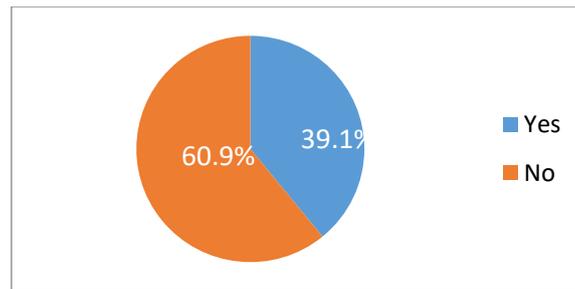


Figure 3. Difficulty studying Embedded System (ES) Subjects because of the way of delivery that is less interesting from the lecturer

3.4. Difficulty studying Embedded System (ES) courses due to inappropriate teaching materials

The use of ES course literature also received positive responses from respondents. In general respondents responded that the cause of their difficulties in ES courses was not due to the literature or teaching material used. Therefore, literature or teaching materials can be considered not the cause of students' difficulties in studying ES courses. Even so, there are still some students who respond that literature is also the cause of their learning difficulties in ES courses. The processed data can be seen in the following Fig 4.

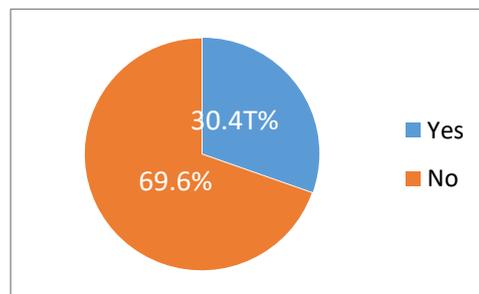


Figure 4. Difficulty studying ES Subjects because of the literature or teaching material

3.5. Difficulty learning Embedded System (ES) courses related to inappropriate learning media

Different responses to points 1 to 4 above are shown in the use of media in learning. In general, respondents gave negative responses to the use of media in learning ES subjects. This shows that the use of media is one of the causes of student learning difficulties in ES courses. The following table shows the processed data from the research questionnaire following fig 5.

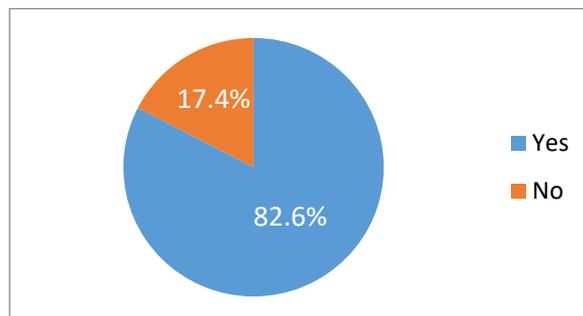


Figure 5. Difficulty studying ES Subjects because the media used is not right

3.6. The Internet of Things (IoT) can be used as an embedded learning system (ES)

The usage of the Internet of Things is one alternate method that can help students overcome their problems in mastering ES courses (IoT). In general, respondents agreed that the Internet of Things is an excellent method for learning ES courses. As a result, IoT can be utilized to help students overcome learning obstacles in ES courses. More, student responses can be seen in the following Fig 6.

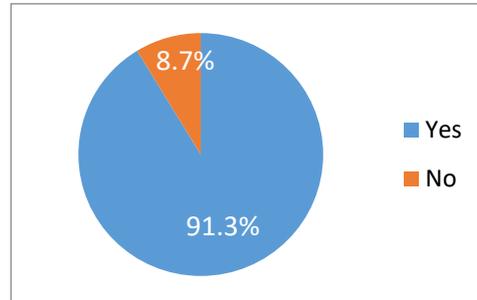


Figure 6. Internet of Things (IoT) can be used as an embedded learning system (ES)

Based on the results in points 1 to 5 above, it can be concluded that the main cause of student difficulties is the use of media which is not appropriate. Information on points 1 to 5 above, can be summarized in the following Table 1. Sequence of factors causing learning difficulties of students in ES courses based on the results of questionnaire processed.

Table 1. Sequence of factors causing learning difficulties of students in ES courses based on the results of questionnaire processed

<i>No</i>	<i>Reasons</i>	<i>Percentage</i>
1	<i>media used</i>	82.6%
2	<i>mastery of the material</i>	78.3%
3	<i>the method used</i>	68.2%
4	<i>literature or teaching material used</i>	69.6%
5	<i>delivery method</i>	60.9%

Based on the factors of student learning challenges in ES courses shown in table 7, one potential approach is to leverage the Internet of Things (IoT). As a result, it is expected that in learning ES courses, IoT will be a useful tool for reducing student learning difficulties. The above findings are consistent with Prihatmoko's research, which found that IoT may be used to increase student learning activities in ES (Prihatmoko, 2016). This is also in line with the findings of Saputra and Hertanto's study, which claims that using IoT in ES learning is one of the advances (Saputra & Hertanto, 2018).

4. CONCLUSION

Based on the results of research that has been carried out on the analysis of student learning difficulties in ES learning, it is concluded that the use of learning media in ES learning is the main factor that students find it difficult to master ES learning. This is because there is currently no available learning media that is relevant to ES learning. The presence of media in the learning process really helps students better understand what they are learning. Therefore, the selection and use of media must be really appropriate so that the desired goals can be achieved easily.

The selection of a type of learning media is one of the most important parts in the learning process in the classroom. The selection of the wrong type of media can cause various effects in the learning process. One of the most frequently encountered consequences is that the learning process that occurs in the classroom is not optimal. This will be the main cause of the final learning objectives are not conveyed properly and cannot be achieved by students.

ES learning was initially taught using AVR or MCS51-based microcontroller material, which explored basic materials such as registers, timers, interrupts, and so on. This basic material is also taught using assembly language where many students do not master it. Currently, ES learning is defined as the interconnection of uniquely identified Embedded Computing Devices in the existing Internet infrastructure. However, currently at the State Polytechnic of Ujung Pandang there is no specific teaching Internet of Things (IoT). For this reason, ES learning lecturers are expected to prepare ES learning media that are integrated with the Internet of Things (ES) to be relevant to the needs of today's industrial world.

5. REFERENCES

- [1] Ajao, L., Agajo, J., Kolo, J., & Adegboye, M. (2016). Learning of embedded system design, simulation and implementation: A technical approach. *American Journal of Embedded Systems and Applications*, 3(3), 35–42. <https://doi.org/10.11648/j.ajes.20150303.12>
- [2] Barua, A., Hoque, M. M., & Akter, R. (2014). Embedded Systems: Security Threats and Solutions. *American Journal of Engineering Research (AJER)*, 03(12), 119–123.
- [3] Budijanto, A., Shoim, A., Elektro, P. T., Kartika, U. W., Buku, P., & Ajar, M. (2015). *Prototipe Modul Pembelajaran Embedded System*. 1–6.
- [4] Darmaliputra, A., & Hermawan, H. (2014). PEMBUATAN WEB SERVER BERBASIS RASPBERRY PI UNTUK KONTROL LAMPU DAN AC. *CALYPTRA*, 3(1), 1–18.
- [5] Dias Prihatmoko. (2016). PENERAPAN INTERNET OF THINGS (IoT) DALAM PEMBELAJARAN. *Simetris*, 7(2), 567–574.
- [6] Ding, N., Wang, Y., Dong, X., & Wang, F. (2017). *Flipped Classroom Based on Micro Learning Resource in Experiment Teaching of Embedded System Design*. 93(Cetcu), 37–40. <https://doi.org/10.2991/cetcu-17.2017.9>
- [7] Heath, T. A. (2011). Divergence Time Estimation using BEAST v2.* Dating Species Divergences with the Fossilized Birth-Death Process. *Beast Tutorial*.
- [8] Hikmawan, F. (2017). Perspektif filsafat pendidikan terhadap psikologi pendidikan humanistik. *Sains Psikologi*.
- [9] Ibrahim, I. (2015). Embedded Systems Pedagogical Issue: Teaching Approaches, Students Readiness, and Design Challenges. *American Journal of Embedded Systems and Applications*, 3(1), 1. <https://doi.org/10.11648/j.ajes.20150301.11>
- [10] Ichsan, M. (2016). PSIKOLOGI PENDIDIKAN DAN ILMU MENGAJAR. *JURNAL EDUKASI: Jurnal Bimbingan Konseling*. <https://doi.org/10.22373/je.v2i1.691>
- [11] Jatmiko, W., Mursanto, P., Al Afif, F., Zaman, B., Rachmadi, M. F., Ma'sum, M. A., Sani, M., Wibowo, A., & Ramdhan, A. (2011). *Implementasi Embedded Systems menggunakan Beagleboard: Prototipe Sistem Pengaturan Lalu Lintas* (Issue January).
- [12] Junior, L. A., Neto, O. T., Hernandez, M. F., Martins, P. S., Roger, L. L., & Guerra, F. A. (2013). A Low-Cost and Simple Arduino-Based Educational Robotics Kit. *Journal of Selected Areas in Robotics and Control (JSRC)*, 3(12), 12.
- [13] Lee, E. A., & Seshia, S. A. (2017). Introduction to Embedded Systems. A Cyber-Physical Systems Approach. Second Edition. In *Studies in Systems, Decision and Control* (Vol. 195).
- [14] Marwedel, P. (2006). Embedded system design. In *Embedded System Design*. <https://doi.org/10.1007/0-387-30087-2>
- [15] Prastika, L. R., Hikmat, D., Si, M., & Waslaluiddin, D. (2015). *Pengaruh Penggunaan Multimedia Interaktif Berbasis Komputer Model Instructional Games terhadap Peningkatan Prestasi Belajar Siswa pada Mata Pelajaran Fisika*. 2015(Snips), 397–400.
- [16] Sababha, B. H., Alqudah, Y. A., Abualbasal, A., & Al, E. A. Q. (2016). Project-based learning to enhance teaching embedded systems. *Eurasia Journal of Mathematics, Science and Technology Education*, 12(9), 2575–2585. <https://doi.org/10.12973/eurasia.2016.1267a>
- [17] Saputra, R. H., & Hertanto, D. B. (2018). Media Berbasis Teknologi Internet of Things (Iot) Mata Pelajaran Teknik Mikroprosesor Di Kelas X Audio Video Smk N 3 Yogyakarta. *E-Journal Universitas Negeri Yogyakarta*, 3, 131–138.
- [18] Toulson, R., & Wilmshurst, T. (2017). Embedded Systems, Microcontrollers, and ARM. In *Fast and Effective Embedded Systems Design*. <https://doi.org/10.1016/b978-0-08-100880-5.00001-3>
- [19] Tsisis, P., Agrawal, N., & Gurriel, N. (2019). An embedded systems perspective in conceptualizing Canada's healthcare sustainability. *Sustainability (Switzerland)*, 11(2), 1–11. <https://doi.org/10.3390/su11020531>
- [20] Tukadi, & Hakimah, M. (2017). Pembelajaran Embedded System Berbasis Arduino Mega 2560 dan MIT App Inventor. *Inform: Jurnal Ilmiah Bidang Teknologi Informasi dan Komunikasi*, 2(1). <https://doi.org/10.25139/inform.v2i1.405>
- [21] Wati, U. A. (2010). Pelaksanaan Pembelajaran yang kondusif dan efektif. *Jurnal Pendidikan*.
- [22] Widiyastuti, N., Slameto, S., & Radia, E. H. (2018). PENGEMBANGAN MEDIA PEMBELAJARAN INTERAKTIF MENGGUNAKAN SOFTWARE ADOBE FLASH MATERI BUMI DAN ALAM SEMESTA. *Perspektif Ilmu Pendidikan*. <https://doi.org/10.21009/pip.321.9>
- [23] Wiyono, K. (2017). Penggunaan Multimedia Interaktif Fisika Modern Berbasis Gaya Belajar Untuk Penguasaan Konsep Mahasiswa Calon Guru. *Jurnal Pendidikan Fisika Dan Keilmuan (JPFK)*, 1(2), 74. <https://doi.org/10.25273/jpfk.v1i2.15>
- [24] Zarpelão, B. B., Miani, R. S., Kawakani, C. T., & de Alvarenga, S. C. (2017). A survey of intrusion detection in Internet of Things. In *Journal of Network and Computer Applications*. <https://doi.org/10.1016/j.jnca.2017.02.009>