A Systematic Review of IoT Platforms in Educational Processes

Irene Cittaning Laksmi, Puspanda Hatta, and Endar Suprih Wihidayat
Faculty of Teacher Training and Education
Sebelas Maret University
Surakarta, Indonesia
irenecitta@student.uns.ac.id, hatta.puspanda@staff.uns.ac.id, endars@staff.uns.ac.id

Abstract

The use of IoT for teaching and learning processes begins to increase. To support the use of the IoT device itself, a platform can be used. The IoT platform gives IoT components the ability to self-regulate so they can help beginners or students deploy IoT devices. Nevertheless, the current state of knowledge in using IoT platforms within the educational field is limited. Therefore, we want to elaborate on how IoT platforms are used to support IoT educational learning tools and enhance educational processes. The research method used is a systematic review and PRISMA is being used as a research protocol. After fifteen articles are screened based on their qualification, we found there are seven platforms frequently mentioned, research results show these learning tools increase students' interest in the subject as well as provide new knowledge of IoT in educational processes for both engineering and non-engineering fields.

Keywords
IoT, IoT platform, education, systematic review, PRISMA

1. Introduction
Internet of Things or as we know as IoT, can be described as a concept that combines various things or objects that applies wireless networks, cables, unique addressing schemes for interacting and working together to create application or service (Vermesan & Friess, 2015). The IoT has been applied in various fields (smart grid, smart homes, smart buildings, public safety and environmental, medical and health, industrial processes, agriculture, and farm) as we can see in Figure 1 that illustrates the increase in Internet-connected or IoT based devices over the last few years (Khanna & Kaur, 2019).

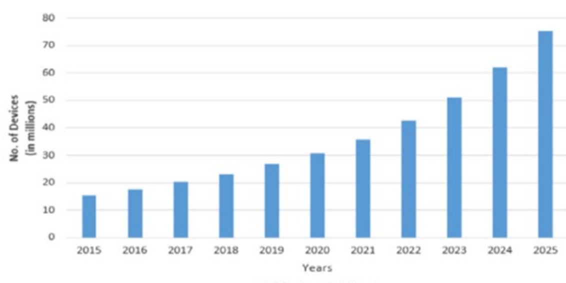

Figure 1. The projected amount of Internet connected devices (Khanna & Kaur, 2019).

The IoT industry looks very promising in providing internet-based devices that can improve the quality of life for individuals, families, and communities. This is also explained by Hammons and Kovac (Hammons & Kovac, 2019) in their book, IoT is used to advance the development in some areas including smart home, healthcare, smart cities, slow tech, agriculture, automotive, supply chain and manufacture.The IoT industry looks very promising in providing internet-based devices that can improve the quality of life for individuals, families, and communities. This is also explained by Hammons and Kovac (Hammons & Kovac, 2019) in their book, IoT is used to advance the development in some areas including smart home, healthcare, smart cities, slow tech, agriculture, automotive, supply chain and manufacture.

There are increase in number of researches that raise IoT as an topic since 2006 (Dachyar et al., 2019). Conducting systematic reviews of IoT have been done before. The goals of the studies such as to provide a wide analysis on the IoT applications and strategies for smart environment (Souri et al., 2019), find out the IoT application trends in healthcare (Haghi Kashani et al., 2021), provides an overview and assessment of the role IoT deployment in oil and gas industry (Wanasinghe et al., 2020), present current advancements in wearable technologies and IoT applications to support activity of daily life (Baig et al., 2019), review business literature related to the IoT (Lu et al., 2018).

IoT is an important agenda on this globalization era including education sector, therefore even in higher education IoT is widely implemented (Rahman et al., 2020). Students can learn through prototyping experiences to help student IoT systems and encourage them to create their own IoT system service ideas (Maenpaa et al., 2017). Using IoT technology for STEM classrooms can also provide good opportunity for innovative teaching and learning (Fidai et al., 2019). If every element of an IoT system is simplified and a prototype system is assembled, even a student majoring in humanities can build an IoT device (Akiyama et al., 2017). Therefore, it is important to introduce IoT devices in education level.

The process of developing IoT applications could be very challenging because of the complexity (Hauß et al., 2020). As IoT projects are getting sophisticated and some of the functions are improved, the integration between the required many of systems of a project is a very complicated, hence there are the platforms that have been introduced to the public for helping IoT applications development (Ammar et al., 2018). The need for effective IoT has resulted in a varied ecosystem of methodologies and tools under realistic conditions in the form of an integrated IoT platform (Terroso-Saenz et al., 2019). IoT platforms are deployed to various objects where IoT devices can communicate with each other and give them the ability to self-regulate (Kashyap et al., 2018). Hence, the usage of IoT platform can be very useful for beginners or in this study context is the students that unfamiliar with the IoT technology.

Regarding the fact as said before, IoT platform application for educational purposes become urgent to be discussed. And yet the current state of knowledge of IoT platforms usage in education is still limited. The gap analysis for this study is to highlight that IoT platforms application can also enhance teaching and learning activities in education.

Therefore, a systematic review with PRISMA protocol is conducted to fill in the gap and stronger findings can be obtained. The goals are to find out about the benefit using IoT platforms, the most used IoT platforms, the implementation and subject areas that use IoT platform for enhancing teaching and learning activities.

2. Literature Review

Internet of Things (IoT) is a concept and paradigm that considers the presence that can penetrate the environment of various things or objects through wireless networks, cables, unique addressing schemes so that they can interact and work together with other objects to create applications or services and communication ranges (Vermesan & Friess, 2015). IoT has become an important agenda in the era of globalization including in education, so that IoT elements have begun to be widely involved in the world of education (Rahman et al., 2020). Educational institutions can benefit from IoT systems such as building automation systems, energy conservation and management systems, building and space access systems, environmental control systems for large research environments, academic learning systems, and safety systems for students, faculty, staff, and the general public (Asseo et al., 2016).

An IoT platform is a framework that can facilitate data communication, data flow, device management, and improve application functionality, but it is not an application itself but all applications can be developed using the IoT platform itself. (J.Perry Matthew, 2016). Systematic research studies on the topic of IoT and IoT platforms have been carried out previously. However, it is not yet difficult to find research in the form of a comprehensive study of the use of IoT platforms in education. Therefore, this research was written with the aim of contributing to literacy regarding the systematic study of the use of IoT platforms in education.

3. Methods

The research method used is a systematic review. Systematic review is considered as the most accurate and appropriate approach to collect articles (Snyder, 2019). Systematic review provides a more rigid and vivid method for reviewing existing literature. It is also well-organized and credible approach to investigate articles from multiple scientific sources and all of the steps will be recorded. This approach helps reducing the risk from less accurate conclusions because of subjective point of view and wrong reports selection (Koutsos et al., 2019). Systematic reviews are used as a scientific method to obtain a wide insight into a specific domain and help researchers in filling the research gap and finding the research studies (Majid & Salam, 2021). In this study, PRISMA is being used as research protocol. PRISMA is designed to help the systematic review method procedures transparently report the goals of conducting the review, reviews procedures have done by the author and the authors' findings (Page et al., 2021).

The research data is sourced from research articles which relevant to the topic of using IoT platforms used in education sector in international journal DOAJ indexed or Scopus indexed. The reason for choosing the database is that there is a claim on the official website as the database includes internationally indexed and high quality articles. The keywords that have been tried to be used in the search for articles on IoT platforms usage in education field such as IoT platform for school, IoT platform for university, IoT platform for learning, IoT platform for teaching. And to broaden the search, IoT platform for education is used as the main keywords.

4. Data Collection

Articles is limited from 2017 to 2021 in April. The reason for choosing the year limit is because of considering the novelty of the researches and the amount of the articles drastically increased since 2017. A total of 15 articles were successfully filtered according to their relevance to the objectives of this study and the reasons the articles are exclude can be seen on Figure 2.

The initial stage of the article screening process is to search the database using predetermined keywords so that a total of 3.309 article titles are obtained. Next is to annul the duplicated titles in a different database and use an automatic filtering tool (define search by title or abstract or keywords) from the database site itself so that the total becomes 186. Next step is to download and access the selected articles so that the total of articles that can be accessed is 172.

These articles were then read and analyzed thoroughly whole document to be tested for eligibility as many as 31 articles. So the number of articles that deserve to be studied in this study are 15 articles. 16 articles are excluded Then After going through the screening process, the next step is to map the selected articles based on the research objectives and the IoT platform used.

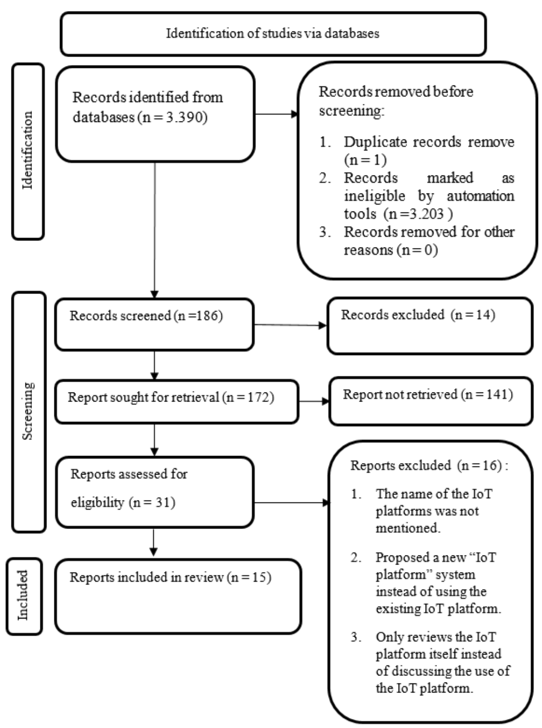

Figure 2. PRISMA flowchart diagram.

5. Results and Discussion

5.1 Numerical Results

The total number of selected articles are 15. After going through the screening process, the next step is to map the selected articles based on research goals and research results, which IoT platform is used as shown in Table 2, based on the purpose as shown in Table 3, and on what subjects the IoT platform is applied as shown on Table 4. The subjects are categorized into engineering and non-engineering. As well as the applications are categorized into two groups, learning media and teaching tools. Learning media is when the students develop or operate the IoT devices on their own. Whereas teaching tools is when the IoT devices is developed or operated by the mentors or teachers.

Table 1. Articles Mapped Based on The IoT Platforms

IoT Platforms	Authors
Blynk	(Asraf et al., 2018), (Setiawan, 2020)
Node-Red IoT	(Andrada Tivani et al., 2020), (Paganelli et al., 2019), (Mayer et al., 2020), (Guerrero-Osuna et al., 2021), (He et al., 2017), (Escobar et al., 2020), (Besari et al., 2017)
FIWARE	(Zaharov et al., 2018)
SiteWhere	(Gunasekera et al., 2018a)
ThingsBoard	(Ga et al., 2021)
ThingSpeak	(Jaklič, 2020)
ThingWorx	(Verner et al., 2020), (Hauß et al., 2020)

Table 2. Articles Mapped Based on Application Strategy

Strategy	Authors
Learning Media	(Ga et al., 2021), (Asraf et al., 2018), (Paganelli et al., 2019), (Gunasekera et al., 2018a), (Mayer et al., 2020), (Guerrero-Osuna et al., 2021), (Setiawan, 2020), (Verner et al., 2020), (He et al., 2017), (Jaklič, 2020), (Besari et al., 2017), (Zaharov et al., 2018), (Hauß et al., 2020)
Teaching Tool	(Andrada Tivani et al., 2020), (Escobar et al., 2020)

Table 3. Articles Mapped Based on Subject Areas

Subject Area	Authors
Engineering	(Ga et al., 2021), (Asraf et al., 2018), (Andrada Tivani et al., 2020), (Mayer et al., 2020), (Guerrero-Osuna et al., 2021), (Setiawan, 2020), (Verner et al., 2020), (He et al., 2017), (Jaklič, 2020), (Escobar et al., 2020), (Besari et al., 2017), (Zaharov et al., 2018), (Hauß et al., 2020)
Non-Engineering	(Paganelli et al., 2019), (Gunasekera et al., 2018a)

There are seven IoT platforms are mentioned, Blynk, Node-Red IoT, FIWARE, SiteWhere, ThingsBoard, ThingSpeak, ThingsBoard. Based on the reviews, there are 2 types of how the researches use IoT platforms on their articles. As a learning media which focus on the student activites and teaching tools which focus on teacher activites. Subject areas are categorized into 2 subject focuses which are engineering and non-engineering.

5.2 Graphical Results

As shown on Figure 3, Node-Red become the most used IoT platforms based on the reviewed articles with the total 7 out of 15 articles. Blynk and ThingWorx come in the second place, with each 2 out of 15 articles. Meanwhile the remaining of the articles choose four different IoT platforms, including FIWARE, Node-Red IoT, SiteWhere, ThingsBoard, and ThingSpeak. There are similarities reason in selecting the IoT platforms that will be described on the discussion section.

As shows on Figure 4 And Figure 5, the articles can be categorized based on the application strategies and the subject areas. The result for both categories shows that most of the articles discussed about learning media application or focused on the application for engineering subject in total 13 out of 15 articles.

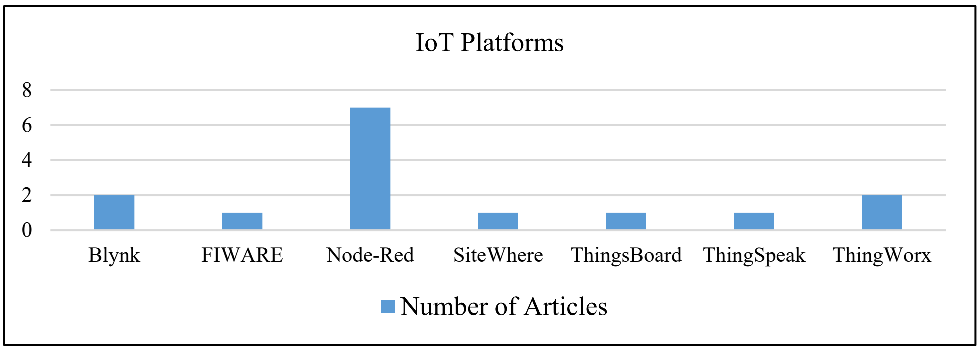

Figure 3. Number of Articles Mapped Based on The IoT Platforms

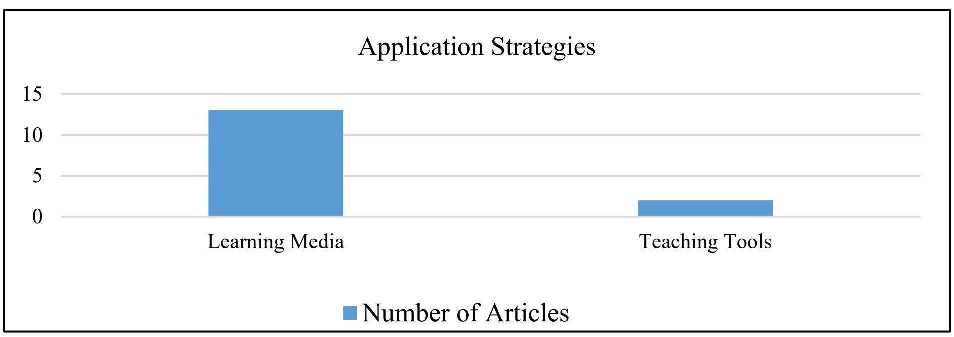

Figure 4. Number of Articles Mapped Based on Application Strategies

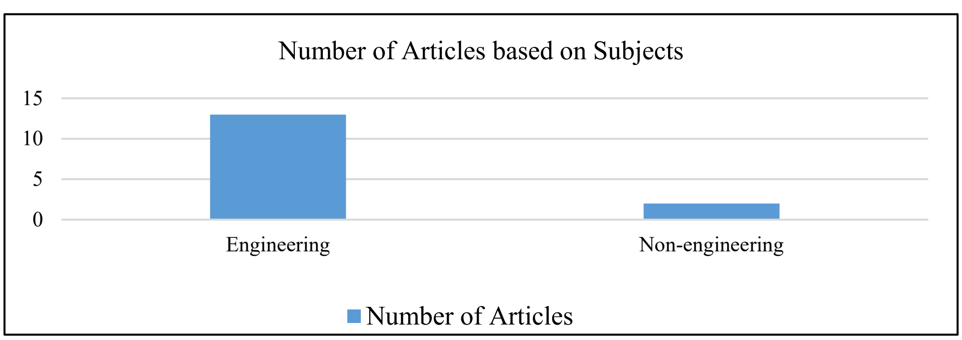

Figure 5. Number of Articles Mapped Based on Subject Areas

5.3 The Benefits of using IoT Platforms for Teaching and Learning Activities

From the articles, the results show the various benefits and roles of IoT in the teaching or learning activities. Especially with existence of IoT platforms that makes it easier to develop IoT based tools that support throughout teaching and learning processes. Therefore, a suitable devices can be implemented in education level not only for industrial purposes. Based on the reviewed articles, an IoT based device for monitoring concentration of carbon, humidity and temperature, also fine dust is successfully developed as a learning media and to answer the three major technical problems that students experiences during scientific inquiries, those include: the difficulty to have a variety of tools for measurements, to provide students with tools that help the complex procedures, and also there is a gap in students' knowledge of technology (Ga et al., 2021).

A low-cost IoT devices for remote laboratory using Node-Red as the IoT platform increase electrical engineering student improvement skills (Andrada Tivani et al., 2020). An IoT field monitoring infrastructure using SiteWhere platform called IoT4SSAE is built for agriculture students that have minimum technical skill (Gunasekera et al., 2018). Another IoT-based weather station that uses Node-Red is adapted to any environment including online teaching without spending a lot of money for infrastructures (Guerrero-Osuna et al., 2021). IoT platform is used for developing an omnidirectional mobile robot that can be applied in educational programs (Verner et al., 2020). A humidity measurement devices using NodeMCU and ThingSpeak as the IoT platform makes students easily use the application even with minimum programming skills (Besari et al., 2017). Educational projects using FIWARE are developed for an effective and modern of the learning activities in the need to provide new requirements for IT students’ skills and knowledge (Zaharov et al., 2018).

IoT platform application made students had full interests in remote lab teaching processes (Asraf et al., 2018). Even IoT device using Node-Red platform was introduced as one of many ways to achieve energy savings and apparently made students interest in this new technology (Paganelli et al., 2019). ThingWorx helped the development of IoT based intelligent robotic device and increase students interest for this subject (Verner et al., 2020). A learning media with ThingSpeak as its platform was introduced and improved students interests in computer science and engineering subject (Jaklič, 2020). In addition, these IoT devices provide students with insight and awareness of technology by developing and operating device itself. With Blynk, students gained new knowledge such as integrating IoT with electrical components and turned into a mobile application as well as increased their digital literacy (Setiawan, 2020). ThingWorx platform was used and increased the students’ awareness of the technology and social changes because of the trends in 4.0 industry (Verner et al., 2020). A learning media for production line using ThingWorx helped students learn various concepts and application of digital twin (Hauß et al., 2020)**.**

IoT platforms helped teaching approaches became more effective. Node-Red helped to develop a low-cost Green Awareness in Action (GAIA) for achieving an increase of quality in teaching (Mayer et al., 2020). With Node-Red, a weather monitoring system device can be developed to any environment without spending more money on infrastructures and hybrid hands-on-learning approach are conducted (Guerrero-Osuna et al., 2021). The development of Mobile Visual Programming Apps that used Node-Red improved the effective learning approach for STEM undergraduate curricula (He et al., 2017)**.**

From the reviews found that the most used learning strategies are by suggesting an IoT-project based or hands-on learning activities, as well as a gamification approach. Where students focussed on creating or redeveloping IoT-based devices. This could help the students to increase knowledge of this new IoT technology. Hands-on learning experiences directly allowed students to experience how this technology works, and it was proven based on previous reviews that it made the teaching process more interesting and effective.

5.4 IoT Platform Selection

There are seven platforms in total are mentioned in the articles. IoT platform that is mostly used is Node-Red. Node-Red was selected for its functions as a sensor or IoT components’ data management and data visualization into a web-based platform, for example as we can see on Figure. 6. The Node-Red platform was used as a data visualization for end-users’ interface as an online platform that was distributed through the internet.

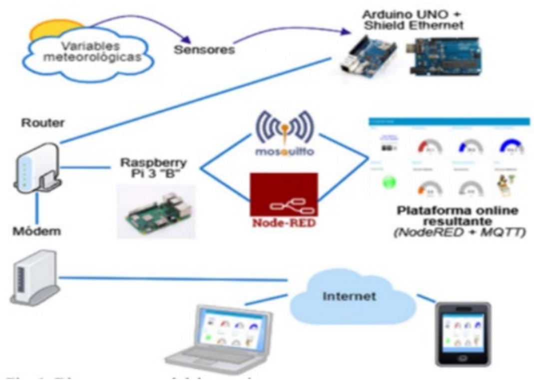

Figure 6. A didactic prototype for a weather station (Andrada Tivani et al., 2020)

In the second place, there are Blynk and ThingWorx. Blynk was tended used for developing an IoT based mobile applications and easy to be used. While ThingWorx was selected for each IoT components' communication and mappings over the internet. The other IoT platforms was being selected based on the researchers requirements and considerations such as being an open source platform (Zaharov et al., 2018), easy to be used (Gunasekera et al., 2018a), there is no limitations for the amount of connected device (Ga et al., 2021), or provide storage and visualization (Jaklič, 2020).

5.5 IoT Platforms Application Strategies

Based on the purpose of implementing the IoT platforms can be categorized into two kinds. As a learning media and a teaching tool. The IoT platform that was used as a learning media focused on the student learning process through the IoT devices. Such as IoT based projects to learn programming and engineering subjects, introducing IoT as new technology (Paganelli et al., 2019), learning other subjects besides IoT and programming like biomedical as shown on Figure7 (Setiawan, 2020), robotics (Verner et al., 2020), production line (Zaharov et al., 2018), or agriculture (Gunasekera et al., 2018b). Meanwhile, for teaching tools, the teachers themselves operated or developed the device to assist in the teaching processes as if MQTT protocol teaching (Andrada Tivani et al., 2020) and multi-robot platform for teaching automation system as shown on Figure 8 (Escobar et al., 2020).

Figure 7. An example of Blynk usage for biomedical engineering learning (Setiawan, 2020).

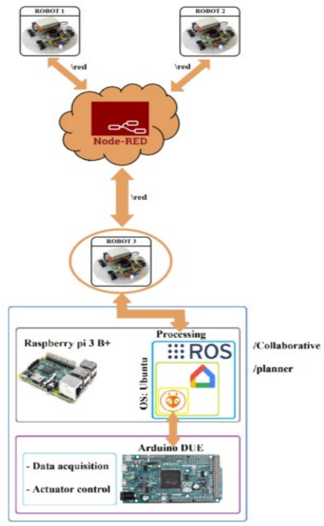

Figure 8. An example of Node-Red usage for automatic system teaching (Escobar et al., 2020).

6. Conclusion

This review focuses on the IoT platform's usage in educational processes especially teaching and learning processes by conducting a systematic review. 15 articles relevant to the topic are screened and analysed. Research results show that there are many benefits that can be provided by using the IoT platforms, not only introducing new technology in the form of IoT devices to students but also increasing student interest and improving the quality of teaching.

Node-Red IoT platform is the most used due to its function that can collect data as well as visualize it on an online platform and helps students to easily understand or operate the device themselves and raise the student interest in the subject. Based on the purposes, it can be categorized into learning media and teaching tools. The subject targets used for the implementation of the IoT platform are not only limited to IoT or programming lessons, in point of fact, but IoT platforms also helped enhance both engineering and non-engineering subjects.

The IoT platform has been proven to help improve the learning and teaching processes and it is important to introduce IoT technology even at the educational level due to the urgency of overcoming technology changes. Therefore, there is a need for future work to increase the number of learning frameworks using the IoT platform**.** Learning frameworks can be established in the form of an IoT-based laboratory, IoT-based teaching devices, or integrating electrical devices with IoT as students' projects. As well as analyze the urgency of considering the introduction of IoT technology as one of our education curricula.

References

Akiyama, K., Ishihara, M., Ohe, N., & Inoue, M. An education curriculum of IoT prototype construction system. *2017 IEEE 6th Global Conference on Consumer Electronics, GCCE 2017*, *2017-Janua*(Gcce), 1–5. 2017.

Ammar, M., Russello, G., & Crispo, B. (2018). Internet of Things: A survey on the security of IoT frameworks. *Journal of Information Security and Applications*, *38*, 8–27. https://doi.org/10.1016/j.jisa.2017.11.002

Andrada Tivani, A. E., Murdocca, R. M., Sosa Paez, C. F., & Dondo Gazzano, J. D. Didactic Prototype for Teaching the MQTT Protocol Based on Free Hardware Boards and Node-RED. *IEEE Latin America Transactions*, *18*(2), 376–382. 2020.

Asraf, H. M., Dalila, K. A. N., Zakiah, M. Y., Amar Faiz, Z. A., & Nooritawati, M. T. Computer assisted e-laboratory using LabVIEW and internet-of-things platform as teaching aids in the industrial instrumentation course. *International Journal of Online Engineering*, *14*(12), 26–42. https://doi.org/10.3991/ijoe.v14i12.8992

Asseo, I., Johnson, M., Nisson, B., Neti, C., Costello, T., & Benson, C. (2016). Why IT Matters to Higher Education: The Internet of Things in Higher Education. *Edcause Review*, *51*(4), 60. 2018.

Baig, M. M., Afifi, S., GholamHosseini, H., & Mirza, F. A Systematic Review of Wearable Sensors and IoT-Based Monitoring Applications for Older Adults – a Focus on Ageing Population and Independent Living. *Journal of Medical Systems*, *43*(8). https://doi.org/10.1007/s10916-019-1365-7.2019.

Besari, A. R. A., Wobowo, I. K., Sukaridhoto, S., Setiawan, R., & Rizqullah, M. R. Preliminary design of mobile visual programming apps for Internet of Things applications based on Raspberry Pi 3 platform. *Proceedings - International Electronics Symposium on Knowledge Creation and Intelligent Computing, IES-KCIC 2017*, *2017-Janua*, 50–54. 2017.

Dachyar, M., Zagloel, T. Y. M., & Saragih, L. R Knowledge growth and development: internet of things (IoT) research, 2006–2018. *Heliyon*, *5*(8), e02264. 2019.

Escobar, L., Moyano, C., Aguirre, G., Guerra, G., Allauca, L., & Loza, D. Multi-robot platform with features of cyber-physical systems for education applications. *2020 Ieee Andescon, Andescon 2020*. 2020.

Fidai, A., Kwon, H., Buettner, G., Capraro, R. M., Capraro, M. M., Jarvis, C., Benzor, M., & Verma, S. Internet of Things (IoT) Instructional Devices in STEM Classrooms: Past, Present and Future Directions. *Proceedings - Frontiers in Education Conference, FIE*, *2019-Octob*. 2019.

Ga, S. H., Cha, H. J., & Kim, C. J. Adapting Internet of Things to Arduino-Based Devices for Low-Cost Remote Sensing in School Science Learning Environments. *International Journal of Online and Biomedical Engineering*, *17*(2), 4–18. 2021.

Guerrero-Osuna, H. A., Luque-Vega, L. F., Carlos-Mancilla, M. A., Ornelas-Vargas, G., Castañeda-Miranda, V. H., & Carrasco-Navarro, R. Implementation of a meiot weather station with exogenous disturbance input. *Sensors*, *21*(5), 1–23. 2021.

Gunasekera, K., Borrero, A. N., Vasuian, F., & Bryceson, K. P. Experiences in building an IoT infrastructure for agriculture education. *Procedia Computer Science*, *135*, 155–162. 2018.

Gunasekera, K., Borrero, A. N., Vasuian, F., & Bryceson, K. P. Experiences in building an IoT infrastructure for agriculture education. *Procedia Computer Science*, *135*, 155–162. 2018.

Haghi Kashani, M., Madanipour, M., Nikravan, M., Asghari, P., & Mahdipour, E. A systematic review of IoT in healthcare: Applications, techniques, and trends. *Journal of Network and Computer Applications*, *192*(January), 103164. 2021.

Hammons, R. L., & Kovac, R. J. (2019). Fundamentals of Internet of Things for Non-Engineers. In *CRC Press Taylor & Francis Group*. 2019.

Hauß, R., Schachinger, G., & Kalteis, G. Work-in-Progress: Industry 4.0 Production Line for Educational Use Multi Stage Production Plant and Interactive AR Model. In *Advances in Intelligent Systems and Computing: Vol. 1134 AISC*. 2020.

He, J. S., Ji, S., & Bobbie, P. Internet of things (IoT)-based learning framework to facilitate STEM undergraduate education. *Proceedings of the SouthEast Conference, ACMSE 2017*, 88–94. 2017.

Jaklič, A. IoT as an Introduction to Computer Science and Engineering: A Case for NodeMCU in STEM-C Education. *IEEE Global Engineering Education Conference, EDUCON*, *2020-April*, 91–95. 2020.

J.Perry Matthew. *Evaluating and choosing an IoT platform - O'Reilly Media*. 2016.

Kashyap, M., Sharma, V., & Gupta, N. Taking MQTT and NodeMcu to IOT: Communication in Internet of Things. *Procedia Computer Science*, *132*(Iccids), 1611–1618.2018.

Khanna, A., & Kaur, S. Evolution of Internet of Things (IoT) and its significant impact in the field of Precision Agriculture. *Computers and Electronics in Agriculture*, *157*(November 2018), 218–231. 2019.

Koutsos, T. M., Menexes, G. C., & Dordas, C. A. An efficient framework for conducting systematic literature reviews in agricultural sciences. *Science of the Total Environment*, *682*, 106–117. 2019.

Lu, Y., Papagiannidis, S., & Alamanos, E. Internet of things: A systematic review of the business literature from the user and organisational perspectives. *Technological Forecasting and Social Change*, *136*(April 2017), 285–297. 2018.

Maenpaa, H., Varjonen, S., Hellas, A., Tarkoma, S., & Mannisto, T. Assessing IOT projects in university education - A framework for problem-based learning. *Proceedings - 2017 IEEE/ACM 39th International Conference on Software Engineering: Software Engineering and Education Track, ICSE-SEET 2017*, 37–46. 2017.

Majid, S. N. A., & Salam, A. R. A Systematic Review of Augmented Reality Applications in Language Learning. *International Journal of Emerging Technologies in Learning*, *16*(10), 18–34. 2021.

Mayer, B., Tantscher, D., & Bischof, C. From digital shop floor to real-time reporting: An IIoT based educational use case. *Procedia Manufacturing*, *45*(2019), 473–478. 2020.

Paganelli, F., Mylonas, G., Cuffaro, G., & Nesi, I. *Experiences from Using Gamification and IoT-Based Educational Tools in High Schools Towards Energy Savings* (Vol. 3). 2019.

Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., Shamseer, L., Tetzlaff, J. M., Akl, E. A., Brennan, S. E., Chou, R., Glanville, J., Grimshaw, J. M., Hróbjartsson, A., Lalu, M. M., Li, T., Loder, E. W., Mayo-Wilson, E., McDonald, S., … Moher, D. (2021). The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. *Systematic Reviews*, *10*(1). 2020.

Rahman, N. A., Idris, M. R., & Baharudin, K. S. (2020). Development of educational kit for IoT online learning. *International Journal of Technology, Innovation and Humanities*, *1*(1), 26–32. https://doi.org/10.29210/881001

Setiawan, A. W. Implementation of internet of things in biomedical measurement and instrumentation course project. *IEEE Global Engineering Education Conference, EDUCON*, *2020-April*, 1657–1661. 2020.

Snyder, H. Literature review as a research methodology: An overview and guidelines. *Journal of Business Research*, *104*(March), 333–339. 2019.

Souri, A., Hussien, A., Hoseyninezhad, M., & Norouzi, M. A systematic review of IoT communication strategies for an efficient smart environment. *Transactions on Emerging Telecommunications Technologies*, *July*, 1–19. 2019.

Terroso-Saenz, F., González-Vidal, A., Ramallo-González, A. P., & Skarmeta, A. F. An open IoT platform for the management and analysis of energy data. *Future Generation Computer Systems*, *92*, 1066–1079. 2019.

Vermesan, O., & Friess, P. Building the hyperconnected society: Internet of things research and innovation value chains, ecosystems and markets. In *Building the Hyperconnected Society: Internet of Things Research and Innovation Value Chains, Ecosystems and Markets*. 2015.

Verner, I., Cuperman, D., Romm, T., Reitman, M., Chong, S. K., & Gong, Z. Intelligent Robotics in High School: An Educational Paradigm for the Industry 4.0 Era. In *Advances in Intelligent Systems and Computing* (Vol. 916). Springer International Publishing. 2020.

Wanasinghe, T. R., Gosine, R. G., James, L. A., Mann, G. K. I., De Silva, O., & Warrian, P. J. The Internet of Things in the Oil and Gas Industry: A Systematic Review. *IEEE Internet of Things Journal*, *7*(9), 8654–8673. 2020.

Zaharov, A. A., Nissenbaum, O. v., Ponomarov, K. Y., & Shirokih, A. v.Use of Open-Source Internet of Things Platform in Education Projects. *Proceedings - 2018 Global Smart Industry Conference, GloSIC 2018*, 1–6. 2018.

Biographies

Irene Cittaning Laksmi is a final undergraduate student pursuing bachelor's in Informatics Education, Faculty of Teacher Training and Education, Sebelas Maret University, Indonesia.

Puspanda Hatta received his master degree in information technology from Universitas Gadjah Mada in 2014. He is currently a senior lecture at the Department of Informatics Education, Faculty of Teacher Training and Education, Universitas Sebelas Maret, Indonesia. He teaches majoring in computer networks discipline such as computer networking, wireless technology, cloud computing, and cybersecurity. His recent research is on applied computer networking and cybersecurity for IT vocational education.

Endar Suprih Wihidayat is a senior lecture in Informatics Education, Faculty of Teacher Training and Education, Sebelas Maret University, Indonesia. He teaches majoring in mobile computing, internet of things, and software engineering. His recent research is on mobile technology application supporting educational purposes.