IoT Application Model in Secondary Education

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Abstract The implementation of certain smart classroom services in the educational process makes it possible to increase the efficiency and quality of the teaching process, as well as the level of competence of students, with low financial investments and a short process of teacher training. The application of the Internet of Things and mobile technologies improves the quality of teaching, making it more interesting for students, thus technologies have significant potential for improving teaching and learning in all educational sectors. The advantage of this way of working is in the application of mobile technologies that students already use. Organizing the teaching process in smart learning environments enables quality and faster communication of students with teachers, active participation of students, and a better type of teaching as well as the efficient exchange of information in the teaching process. The research presented in the paper aims to point out the possibilities of improving the learning process in secondary education by applying pervasive technologies. The proposed model was evaluated with secondary school students.

Keywords e-learning · Secondary school · Internet of things · Pervasive technologies · Smart learning environments

1 Introduction

Internet of Things and mobile technologies are suitable for use for educational purposes because they do not require large infrastructure investments [1, 2]. Although an ideal smart classroom is expensive, a lot of functionality can be realized at a low cost [3–5]. Innovations can also be realized through new pedagogical approaches of teachers with small investments. Also, theoretical analyzes from the scientific literature and the results of previous research show that in higher education there

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are numerous experiences that can be adapted and applied to the improvement of secondary education [7, 8]. For developing countries, a better approach is the implementation of certain smart classroom services that would enable, with low financial investments and a short process of teacher training, to increase the efficiency and quality of the teaching process [9–11].

Analyzes of scientific research show that the Internet of Things (hereinafter: IoT) has great potential for application in formal secondary education [9, 12–14]. Their inclusion would improve the teaching process in secondary schools, and students would receive a modern and efficient education system, suitable for modern technological development.

Scientific research projects show that adequate equipping of secondary schools with modern technology is a prerequisite for effective improvement of teaching in secondary schools [15, 16]. In addition, teachers must be continuously educated, as well as develop and apply innovative e-learning methods [17].

Technologically advanced teaching aids enrich the educational process daily, creating smart learning environments. Smart learning environments are mainly based on IoT and mobile technologies [18]. IoT enables resource virtualization by presenting a concept that extends the Internet and the virtual world to physical things from the real world [19].

Smart environments are realized through various technologies, hardware, and software components, so the IoT value chain itself consists of several different categories: sensors, actuators, radio/communication chips, microcontrollers, modules, software platforms, application software, telecom infrastructure, service infrastructure [20].

The goal of this paper is to point out the possibilities of improving the learning process in secondary education by using pervasive technologies in the learning process.

2 Literature Review

2.1 Electronic Education in Secondary Schools

Newer generations of secondary school students view the world through the prism of computers, mobile phones, cameras, players, video games, and other modern information technology devices, which give them the ability to perform multiple tasks at once and at the same time listen to music, surf the Internet or chat online while doing homework [21].

With the technological development of society, the importance of education is growing, which thus becomes a condition for the survival and progress of modern society [11, 15]. In line with that, there is an increasing need for educational activities to be realized regardless of location and time. However, the question is whether the standard educational process can meet such requirements. The application of modern technologies in the educational process can certainly enable that [16].

The creation of smart learning environments has also improved e-learning, which is being upgraded by using technologies of smart learning environments. Smart education is considered to be education supported by technologies, smart tools, and devices. Specific concepts of e-learning are collaborative and mobile learning, which have the potential to support the development and application of crowdsourcing in smart learning environments [17].

2.2 Technologies of Smart Learning Environments

A smart environment is an ecosystem composed of objects, i.e., sensors, and actuators that interact with each other and can manipulate and process large amounts of data to automate actions that are often repeated [18, 19]. IoT enables the virtualization of resources by presenting a concept that extends the Internet and the virtual world to physical things from the real world. Physical things have the possibility of virtual representation by connecting to the Internet and unambiguous identification. IoT can also be defined as a higher level of pervasive technologies and intelligence, where components, products, services, and platforms are connected, and everything is integrated into a communication network for digital processing. IoT is based on several different disciplines and technologies, including sensors, communication technologies, semantic and security technologies, but also requires a specific configuration for object identification, lightweight protocols, open/closed data sharing, etc. [20].

The management of a smart learning environment is based on core values, such as human rights, ethics, the common good, legislation, and transparency of educational procedures [21].

Smart environments are realized through various technologies, hardware, and software components, so the IoT value chain itself consists of several different categories [22]:

1. Sensors—generate most data;
2. Actuators—perform actions;
3. Radio/communication chips—enable connectivity;
4. Microcontrollers—process data;
5. Modules—combine radio, sensors, and microcontrollers and allow them to be added to the device;
6. Software platform—enables management and capabilities of the IoT network;
7. Application software—provides the collected information in a format that is suitable for end-users, so that they can use and analyze it;
8. Telecom infrastructure—enables mainly wireless data transmission;
9. Service infrastructure—enables design, installation, monitoring, and servicing of IoT implementation.

The most famous smart environments are smart classrooms. In smart learning environments, several different technologies are used to develop crowdsourcing models. The model is being developed in smart learning environments, so it is necessary to

use IoT technologies. The development of crowdsourcing systems requires the use of web and internet technologies, as well as technologies for building portals [9, 23].

Portals bring together information from different sources and present it to portal visitors. In this way, different goals can be achieved, which relate to informing users, advertising, connecting users, etc. Today's portals are even more important because they enable user interaction and their direct involvement [15, 24].

3 Model Development

Modeling the environment for secondary education is a way to connect the services of the IoT into a unique and planned organized technological, organizational, and educational system, aimed at the overall improvement of secondary education. The proposed model of e-education in smart learning environments includes the following components: e-education system framework, smart classroom architecture, smart classroom software infrastructure, integration of IoT infrastructure components with e-education system, e-education system services, and new pedagogical approaches in e-education (Fig. 1).

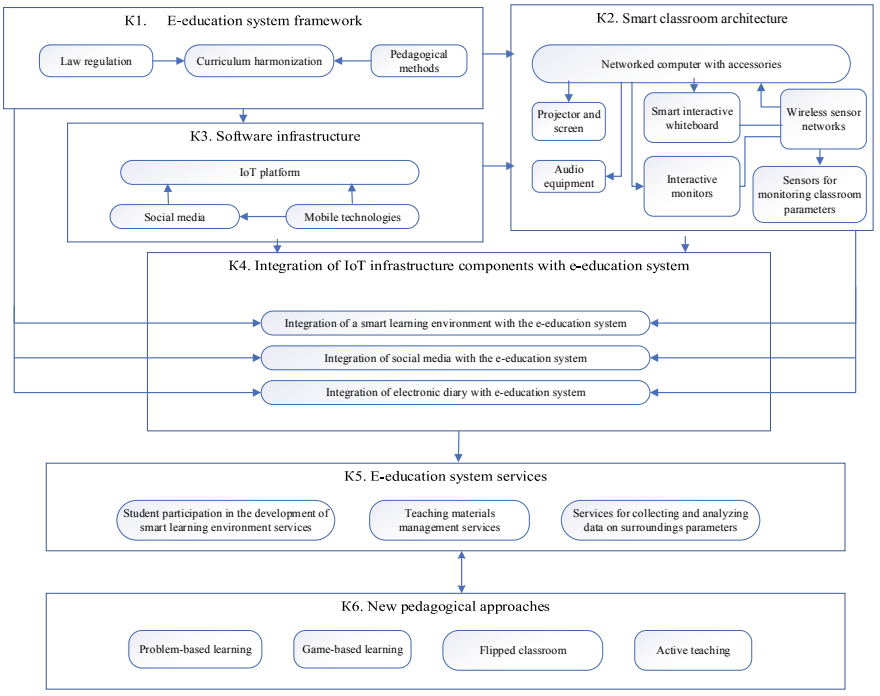

Fig. 1 General structure of the model of secondary school e-education based on the IoT

The e-education system framework is the first component in the structure of the secondary school e-learning model based on IoT technologies. It includes law regulations, curriculum harmonization, and pedagogical methods. Implies harmonization of law regulations and pedagogical methods with curricula.

The next component is **smart classroom architecture**, which involves designing a smart learning environment for secondary school education.

The smart classroom represents a projected smart learning environment for secondary education [9].

When creating smart classrooms, it is necessary to make a compromise between the initiatives and wishes of teachers, students, and parents. The smart classroom should provide easy access to information via an intranet, internet, electronic diary, assessment and learning management system, digital content, school website, then through individual or specific content made for individual departments or classes, as well as through blogs, wikis, and social media that are used in school and are easily accessible.

To design a smart learning environment for secondary education, it is necessary to have in the classroom: networked computer with accompanying equipment, smart interactive whiteboard, interactive monitors, projector and screen, wireless sensor networks, audio equipment, sensors for monitoring classroom parameters.

By measuring parameters related to the physical environment, such as lighting, air quality, noise, or room temperature, student satisfaction can be accurately determined during class. Using various devices or mobile phones with sensors, some of the parameters of the physical environment can be easily measured. Based on these parameters, a smart classroom can be designed, which will be able to analyze the parameters of the physical environment to determine student satisfaction with the quality of teaching at a given time. Thus designed and implemented smart classroom systems, according to research, can determine how satisfied students are with the quality of lectures with an accuracy of more than 93% [25].

The software infrastructure of the smart classroom consists of the IoT platform, social media, and mobile technologies.

IoT platforms should integrate heterogeneous devices, as well as store and manage data collected from sensors. To achieve a high degree of scalability, reliability, redundancy, and better use of available computing resources, it is desirable to use a cloud platform. Most elements of the IoT platform are cloud-based and wirelessly connected by a combination of different technologies, including mobile technologies, web services, and the like [26, 27].

When it comes to IoT devices that can be used in secondary school education, Raspberry Pi microcomputers (RPi) and Arduino microcontrollers appear to be good solutions. Using these devices, IoT solutions that do not require specialized components or expert knowledge for implementation can be easily created [28].

Some examples of open source IoT platforms that can be used in education are the *ThingSpeak Platform* and the *Mainflux Platform.*

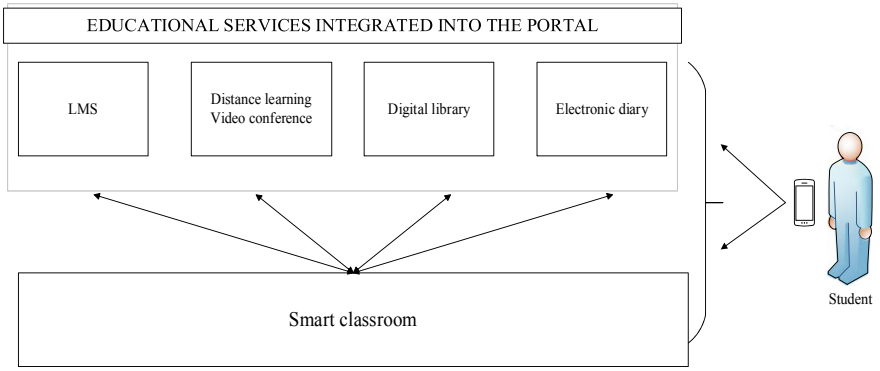

Fig. 2 Educational services in a smart learning environment

Both platforms are suitable for use in a smart educational environment. From the aspect of economic profitability, it is important that the implementation, implementation, and development of a smart environment are simple and do not require large costs.

Within the software infrastructure, there are social media and mobile technologies that are connected to the IoT platform. The paper [24] presents an approach to the development of a web portal for adaptive e-learning. Mobile and wireless technologies have the task of enabling communication and cooperation between intelligent devices, mobile devices, and the Internet [29].

The integration of IoT infrastructure components with the e-education system is the fourth component in the model. It represents the unity of the work of the previous three explained components as a whole. It consists of several parts: integration of a smart learning environment with the e-education system, integration of social media with the e-education system, integration of the electronic diary with the e-education system (Fig. 2).

Today, learning is no longer limited to the school and the classroom, and educational institutions provide a large number of extracurricular activities to improve students' knowledge and skills. But, while earlier information was obtained in libraries or computer rooms, now it can and must be available to everyone regardless of place and time.

By setting up *WiFi* access points in the school, students are given access to the school computer network and the Internet. Within the school, areas should be created where students will have the opportunity to use digital tools continuously, and materials for classes should be published on the school portal, which students could access and download.

E-learning system services include student participation in the development of smart environment services, services for managing teaching materials, services for collecting and analyzing data on environmental parameters.

Students can develop their services and share them with other students, and by integrating student services with cloud-based services and external web APIs, more complex services can be assembled.

Creating reports based on reading data from sensors is a typical scenario in applications of Internet intelligent devices, so students are provided with a simple API for this purpose. It allows the storage, use, and sharing of data read from sensors, as well as the input or generation of external data, to stimulate some specific conditions, which cannot be directly measured in the educational environment.

For the e-learning model based on the IoT to be successfully established in secondary education, teaching equipment and infrastructure are needed. The limiting factor in this may be financial resources, given that it is necessary to provide equipment for the design and implementation of various services of IoT.

Equipping classrooms with smart teaching aids is organized on two levels. The first level is global and includes the implementation of a solution that will be used by all classroom users. The second level is individual and involves equipping workstations [26].

The last component in the model is **new pedagogical approaches in e-education**.

Examples of some of the pedagogical models that can be applied in secondary school teaching are the following: Problem-based learning, Game-based learning, Flipped classroom, Active teaching [7, 30–32].

4 Evaluation

The evaluation of the presented model was conducted with the students of the Secondary School of Economics in Belgrade. The results of the evaluation are presented in the article [9], and they show that the implemented model of e-education based on IoT devices has enabled an increase in the level of knowledge and interest of students to learn using smart devices and mobile phones in the process of knowledge assessment.

Following the example of the proposed model, the research was conducted in higher education, with students of the Faculty of Organizational Sciences, University of Belgrade. A smart learning environment system has been developed for the research. The evaluation is presented in an article [23], and the results obtained showed that students achieve better results by using modern technologies in the learning process compared to traditional ways of learning. Increased motivation, as well as a high level of interest, is relevant to the way of working with the application of pervasive technologies.

The conducted research indicates that new methodological approaches to teaching can contribute to better vertical integration of secondary and higher education in the educational process.

5 Conclusion

The main goal of the research is the efficient and effective improvement of teaching in secondary schools by applying the concepts and technologies of the IoT. As part of the evaluation of the model, testing and measurement of relevant parameters were realized.

One of the preconditions for the efficient use of pervasive technologies in education is the adequately equipping secondary schools with modern equipment and technology. After that, continuous theoretical and practical education of teachers is necessary, so that they first understand and accept the role of pervasive technologies in the teaching process, and then they can pass it on to students.

It is quite certain that in that way, the educational process in secondary schools would be significantly improved, enhanced, and raised to a much higher level, and students would get a modern and more efficient education system suitable for modern technological development.

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References

1. Aduwa-Ogiegbaen, S.E., Iyamu, E.O.S.: Using information and communication technology in secondary schools in Nigeria: problems and prospects. J. Educ. Technol. Soc. **8**(1), 104–112 (2005)
2. Cakir, R., Yildirim, S.: Who are they really? A review of the characteristics of pre-service ICT teachers in Turkey. Asia-Pac. Educ. Res. **24**(1), 67–80 (2015)
3. Asterhan, C.S., Rosenberg, H.: The promise, reality and dilemmas of secondary school teacher–student interactions in Facebook: the teacher perspective. Comput. Educ. **85**, 134–148 (2015)
4. Salleh, S.M., Laxman, K.: Investigating the factors influencing teachers' use of ICT in teaching in Bruneian secondary schools. Educ. Inf. Technol. **19**(4), 747–762 (2014)
5. Sanders, M., George, A.: Viewing the changing world of educational technology from a different perspective: present realities, past lessons, and future possibilities. Educ. Inf. Technol. **22**(6), 2915–2933 (2017)
6. Beetham, H., Sharpe, R.: An approach to learning activity design. In: Rethinking Pedagogy for a Digital Age: Designing for 21st Century Learning, pp. 26–40. Routledge, Taylor & Francis Group (2013)
7. Stojanović, D., Bogdanović, Z., Despotović-Zrakić, M., Naumović, T., Radenković, M.: An approach to using Instagram in secondary education. In: The 14th International Conference on Virtual Learning ICVL, pp. 247–253 (2019)
8. Michailidis, N., Kapravelos, E., Tsiatsos, T.: Examining the effect of interaction analysis on supporting students' motivation and learning strategies in online blog-based secondary education programming courses. Interact. Learn. Environ., 1–12 (2019)
9. Stojanović, D., Bogdanović, Z., Petrović, L., Mitrović, S., Labus, A.: Empowering learning process in secondary education using pervasive technologies. Interact. Learn. Environ. **1**(1), 1–14 (2020)
10. Stojanović, D., Domazet, I.: Use of information technologies in educational purposes-case from Serbia. Econ. Anal. **53**(2), 68–78 (2020)

11. Stankić, R., Jovanović-Gavrilović, B., Soldić-Aleksić, J.: Information and communication technologies in education as a stimulus to economic development. Ekon. Horizonti **20**(1), 61–73 (2018)
12. Glaroudis, D., Iossifides, A., Spyropoulou, N., Zaharakis, I.D., Kameas, A.D.: STEM learning and career orientation via IoT hands-on activities in secondary education. In: In IEEE International Conference on Pervasive Computing and Communications Workshops (PerCom Workshops), pp. 480–485 (2019)
13. Mavroudi, A., Divitini, M., Gianni, F., Mora, S., Kvittem, D.R.: Designing IoT applications in lower secondary schools. In IEEE Global Engineering Education Conference (EDUCON), pp. 1120–1126 (2018)
14. Palagolla, W.W.N.C.K., Wickramarachchi, A.P.R.: Effective integration of ICT to facilitate the secondary education in Sri Lanka. arXiv Prepr. arXiv1901.00181 (2019)
15. Stojanović, D.: Analiza realizacije učenja na daljinu u Srbiji za vreme pandemije virusa COVID 19. In: Black swan in the world economy 2020. Institut ekonomskih nauka, Beograd, pp. 121–140. ISBN 978-86-89465-54-9 (2020)
16. Maletić, M., Barać, D., Naumović, T., Bogdanović, Z., Radenković, B.: Blending Crowdvoting in Modern e-Learning Environments. Int. Rev. Res. Open Distrib. Learn. **20**(2) (2019)
17. Zahirović Suhonjić, A., Despotović-Zrakić, M., Labus, A., Bogdanović, Z., Barać, D.: Fostering students' participation in creating educational content through crowdsourcing. Interact. Learn. Environ. **27**(1), 72–85 (2019)
18. Palma, D., Agudo, J.E., Sánchez, H., Macías, M.M.: An internet of things example: classrooms access control over near field communication. Sensors **14**(4), 6998–7012 (2014)
19. Petrović, L., Jezdović, I., Stojanović, D., Bogdanović, Z., Despotović-Zrakić, M.: Development of an educational game based on IoT. Int. J. Electr. Eng. Comput. **1**(1), 36–45 (2017)
20. Lakshmi, I.: A vision, architectural elements, and future direction of internet of things (IoT). Int. J. Sci. Res. Comput. Sci. Eng. Inf. Technol. **3**(1), 306–328 (2018)
21. Garcia, A., Marquez, J., Solarte, Z., Villanueva, J.: IoT in education: integration of objects with virtual academic communities. In: New Advances in Information Systems and Technologies, vol. 444, pp. 201–212. Springer, Verlag (2016)
22. Friess, P., Riemenschneider, R.: New horizons for the Internet of Thing in Europe. In: Building the Hyperconnected Society—IoT Research and Innovation Value Chains, Ecosystems and Markters. River Publishers, Denmark (2015)
23. Petrović, L., Stojanović, D., Mitrović, S., Barać, D., Bogdanović, Z.: Designing an extended smart classroom: an approach to game-based learning for IoT. Comput. Appl. Eng. Educ. (2021)
24. Radenković, B., Despotović-Zrakić, M., Barać, D., Bogdanović, Z., Milić, A.: Web portal for adaptive e-learning. In: 2011 10th International Conference on Telecommunication in Modern Satellite Cable and Broadcasting Services (TELSIKS), pp. 365–368 (2011)
25. Gligoric, N., Uzelac, A., Krco, S., Kovacevic, I., Nikodijevic, A.: Smart classroom system for detecting level of interest a lecture creates in a classroom. J. Amb. Intell. Smart Environ. **7**(2), 271–284 (2015)
26. Bogdanović, Z., Simić, K., Milutinović, M., Radenković, B., Despotović-Zrakić, M.: A Platform for Learning Internet of Things. Int. Assoc. Dev. Inf. Soc., 259–266 (2014)
27. Perry, M.J. Evaluating and Choosing an IoT Platform. O'Reilly Media (2016)
28. Milutinović, M., Simić, K., Labus, A., Bogdanović, Z., Despotović-Zrakić, M.: Platforma za učenje interneta inteligentnih uređaja. In: XIII međunarodni naučno-stručni simpozijum INFOTEH-JAHORINA 2014, vol. 13, pp. 759–762 (2014)
29. Basole, R.C., Karla, J.: On the evolution of mobile platform ecosystem structure and strategy. Bus. Inf. Syst. Eng. **3**(5), 313–322 (2011)
30. Petrović, L., Stojanović, D., Labus, A.: Development of an educational game: Augmented reality approach to edutainment. In: XVI International Symposium Doing Business in the Digital Age: Challenges, Approaches and Solutions SymOrg 2018, pp. 96–107 (2018)

31. Maenpaa, H., Varjonen, S., Hellas, A., Tarkoma, S., Mannisto, T.: Assessing IOT projects in university education—a framework for problem-based learning. In: Proceedings—2017 IEEE/ACM 39th International Conference on Software Engineering: Software Engineering and Education Track, ICSE-SEET 2017, pp. 37–46 (2017)
32. Ivanović, B.: 'Flipped classroom': pedagogical model that changes the concept of traditional teaching. Ekon. signali Posl. Mag. **13**(1), 57–66 (2018)