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FIRST STEP TOWARDS SMART CLASSROOM - IOT DEVICE FOR REGISTERING STUDENTS TO CLASSES

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Abstract: *The use of IoT devices in the classroom has the potential to revolutionize the learning experience of students and professors. One such device is the NodeMCU, an open-source platform based on the ESP32 microcontroller. This paper presents device for registering students for classes and preparation for the experiment, which is conducted on our faculty where we work as teaching fellows, on the use of NodeMCU. In the first part of the paper, we will briefly look at some of the challenges in higher education in the Republic of Serbia and how we came up with the idea to improve the teaching process by creating a device for registering for classes. Next, we will explain in more detail the building elements of the device itself and how it works.*
Keywords: *IoT, NodeMCU, Arduino IDE, smart classroom, teaching process*

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1. Introduction

Although we have already stepped deep into the new industrial revolution, the so-called Industrial Revolution 4.0 or 4IR (Culot et al., 2020) in certain industries little has changed compared to previous decades (Ghashim & Arshad, 2023; Kamruzzaman et al., 2023; Zhang & Li, 2021). An excellent example of this is education, which is carried out in a similar, if not identical, way to the beginning of the twentieth century. When we talk about education in this paper, it refers to education in the Republic of Serbia, with a focus on higher education. We still have classrooms where students come to listen to professors' theoretical presentations with very little or in some cases total absence of interactivity, which affects the acquisition of knowledge if we consider how difficult it is to maintain the attention span of young people who are exposed to content from all sides who wants to win and keep their attention at any cost. Also, many faculties still do not have an information system, but records about teachers, students, classes are kept in excel tables, and the attendance of students is recorded by a paper provided by professor so that the students can write their names, after which the professor either keeps that paper or keeps records in his excel table or notebook. Considering how important education is for the progress of a society as a whole and how much time the average person spends in the

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classroom, it would be a big mistake not to use the intellectual potential of young people (Friend et al., 2023).

Currently, there is no uniform approach to how higher education institutions should deal with this problem and include new technologies in teaching, but each institution is allowed to decide for itself whether and how many changes it will make in its teaching process, of course with compliance with the mandatory procedures defined by the Law . We can say that the pandemic of the COVID-19 virus in 2020. greatly influenced the faster adoption of new technologies and marks the beginning of the realization of a new reality.

As a group of young teaching fellows and professors who should be the change we want to see, we came up with the idea to improve the teaching process for a nuance and create a device that will enable students to quickly register for classes. The experiment was conducted on the practical classes of several subjects that we teach at the faculty where we work. In this paper, we will explain the preparation for conducting the experiment, i.e. the very process of making the device that we called – *Present*. With this device, we have come a little closer to what is called a smart classroom, and therefore a smart university.

2. Smart Classrooms

A smart university is any university that implements IoT (internet of things), cloud computing, Big Data and/or machine learning (Wang et al., 2022; Rico-Bautista et al., 2021; Petchamé et al., 2021).

Since the main feature of a university should be learning, and it is mostly carried out in classrooms, specialized cabinets, amphitheatres and other types of classrooms, we will focus on the concept of the smart classroom. A smart classroom can be a classroom that has an interactive whiteboard with a projector, or some other type of audio-visual teaching method, and it can also be something much more sophisticated, such as teaching in virtual reality (VR) or augmented reality (AR). The COVID-19 pandemic had a positive impact on the development of smart classrooms, because many universities had to quickly get used to holding classes online or hybridly, for which they needed cameras, microphones and some online platform (cloud computing) as a minimum for the entire communication, as well as teaching, between professors and students took place.

The use of technology in the classroom has become increasingly important. Smart classrooms, in particular, have gained popularity due to their ability to enhance the learning experience of students. Smart classrooms are equipped with various technological tools and devices that can be used to improve teaching and learning (Harmer & Szeles, 2022; Mrabet & Moussa, 2017).

One of the benefits of smart classrooms is the efficient use of technology. For example, lecturers can prepare PowerPoint presentations and upload them to a Learning Management System rather than having to print a copy for each student. Students can read their course materials on their smartphones even while in bed, rather than having to go to the computer labs on the campus before having access to the materials. The use of technology in this way can save time and resources, making the learning process more efficient.

Another benefit of smart classrooms is the ability to enhance student motivation and engagement. Technology can be used to create interactive and engaging learning experiences that can help students stay focused and motivated.

Smart classrooms can also help students develop digital literacy skills, which are in high demand in the workplace. By integrating technology in the classroom, students learn to navigate digital platforms, use productivity tools, collaborate online, and effectively

communicate using digital mediums. This can help students become more competitive in the job market and better prepared for the digital age.

In conclusion, smart classrooms have the potential to revolutionize the learning experience of students. The use of technology in the classroom can enhance teaching and learning, improve student motivation and engagement, and help students develop digital literacy skills. However, it is important to ensure that students are guided on effectively searching for information, critically evaluating sources, and using technology responsibly. Teachers are crucial in helping students navigate the digital world and ensuring that technology is used in a way that enhances the learning experience of students.

3. NodeMCU

For the hardware/firmware solution of the device itself, we decided on the NodeMCU board (MCU in the name refers to the microcontroller, i.e. microcontroller unit), an accessible open source platform (development board) based on the ESP32 SoC, i.e. microcontroller. Although it contains MCU NodeMCU is not only a microcontroller but an entire development board, and the terms development board and microcontroller are often used interchangeably. Before proceeding further, we will first clarify the terms used.

A microcontroller is a simple computer that sits on one integrated circuit (IC) and runs one program at a time and repeats it until it is told otherwise, ie. until instructed otherwise. (*What Is a Microcontroller and How Does It Work?*, n.d.) Examples of microcontrollers are PIC, AVR, ESP8266, ESP32. The ESP8266 is an older version of the microcontroller on which the older NodeMCU versions are based. A microcontroller is most often used for short and simple tasks, for example opening/closing a garage door. The development board (platform) takes the microcontroller and expands it with interfaces for connecting to the outside world - usb, hdmi, ethernet, alphanumeric LCD, power input port, etc. (Ibrahim, 2021). Examples of development boards are Arduino Uno, NodeMCU, Raspberry Pi, etc. Depending on the problem we want to solve, we decide on one or the other platform. In our case, the key part of the application itself is the connection to the Wi-Fi network, so we decided on the NodeMCU because this is precisely the main feature of the NodeMCU board. For example, Raspberry Pi provides much greater capabilities than what we needed, and therefore is more expensive, so we would not use most of its resources and the whole solution would cost us more.

As we have seen, the ESP32 Wi-FI SoC is the microcontroller itself that the NodeMCU platform we have chosen uses, and whose development and maintenance is in charge of Espressif Systems, and due to its easy integrability and high performance, it represents an excellent solution for various IoT (internet of things) projects based on Wi-Fi connection (Teel, 2021). Another advantage of the NodeMCU platform is that it is compatible with Arduino's IDE (integrated development environment), especially since we already had experience with Arduino's development environment on previous projects. With that, we were able to quickly and easily write and optimize the server according to our needs in the Arduino programming language. Arduino's programming language is based on the C++ programming language.

On the microcontroller, we have set up a server whose responsibility is to forward the page for students to register for classes. NodeMCU is connected to the teacher's computer in the classroom, but no additional setup of the microcontroller by the professor is required. This is important if we consider that the extra burden on professors with tasks to complete at the beginning of each class could actually slow down the process of student registration and the start of each class. The only thing the teacher needs to do is to start the lesson by entering the teaching unit. The solution of system for monitoring classes itself was not the subject of this experiment.

Students log on to the ESP32 access point and get an interface where they enter their student ID. Initially, a QR code was forwarded, but during the experiment itself, such an approach was abandoned and we switched to a solution with a URL address. Since students log in through the access point of the microcontroller, the registration of students who are not physically in class is prevented.

4. Application

The application solution was written using web technologies - HTML, CSS, JS and PHP. In this way, the student can also log in via his or her phone if the classroom has only one computer intended for the professor to conduct classes. When the student enters a valid student ID for the corresponding period, the form is forwarded to the API, where the registered student is entered into the database, and the student himself is disconnected from the access point. In this way, it frees up its place for other students and does not load the server anymore.

If the specified student ID is not valid, an error message is thrown. Also, a student who has already registered attendance at one appointment cannot do so again. A valid student ID is any student ID that has the right to take a course with the corresponding professor in the current academic year. Data on this is usually maintained by the student service of the faculty and should be delivered to professors before the start of classes in the semester or, if there is a system for monitoring classes, directly enroll and assign students to courses with selected professors.

The database keeps records of students, professors, subjects, teaching unit, microcontroller and students in a teaching unit (a professor holds a lesson on a subject with a group of students at the appropriate time and in a specific lecture hall). Each microcontroller is linked to the classroom with a unique identification number in the database. Although it is always active, students can only log in while the class in the corresponding classroom is active. Currently, there is no time limit for registering for classes, since some professors do it at the beginning, some at the end of the class, and we took into account the limitation of the selected microcontroller on the number of connections at one time. This could certainly be one of the proposals for expanding and improving the current solution.

As a result, the professor no longer has to keep records of attendance since everything is in one centralized place where the professor can at any time see which student has how many attendances, and if they are scored at the end of the semester, he or she can add them to the total number of points that student achieved during the semester. If the faculty already has a system for monitoring classes, then the *Present* can be integrated into it, and in this way the professor would receive a proposal for the final grade at the end of the semester if each attendance was recorded through the *Present* and if the professor entered points from the colloquium, seminar papers and exams in the teaching monitoring system. In this way, every part of this digital educational puzzle, whether it is an information system, a system for monitoring classes or a *Present*, no matter how small it may seem, contributes to the ultimate goal, which is the gradual introduction of education into the new industrial revolution.

As you can see, the entire application is not overly complicated, which was the goal since we wanted it to be as fast as possible and to serve its primary purpose, which is to enable students to register for classes. If the needs of the faculty and the course itself require it, the application can easily be expanded, for example, by adding quiz questions during the class, which would check students' knowledge and award points for class attendance, or by enabling the solving of various surveys that are usually given to students in paper form.

All these data would then be stored in the database, and together with the above-mentioned data, various analyzes could be performed on them and suggestions made for the improvement and optimization of teaching in the subject.

5. Conclusion

It can be concluded that the use of IoT devices, specifically NodeMCU, in the classroom can improve the education process. The IoT devices can be used for various purposes, such as registering students for classes, detecting the number of people and their distribution in a classroom, and providing a higher level of personalized active learning environment. The use of NodeMCU in particular provides an accessible open-source platform for IoT projects based on Wi-Fi connection, making it a suitable choice for classroom applications. The compatibility of NodeMCU with the Arduino IDE also makes it easy to program and prototype.

Overall, the use of IoT devices in the classroom can overcome the disadvantages of online education, speed up the process and even remove traditional barriers of teaching and learning. IoT devices can be used to create a smart classroom and improve the overall experience and content of students. In conclusion, the use of IoT devices, specifically NodeMCU, in the classroom has the potential to enhance the experience of students and professors and create a more interactive and engaging environment.

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