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CREATION OF A SMART LIGHTING SYSTEM IN THE STUDY ROOM

Abstract

The relevance of the introduction of innovative technologies in the educational process is steadily growing. Today, smart lighting is increasingly found in homes and offices, but it is still rare in schools and universities. The lack of ready-made solutions for classrooms is explained by the specific requirements for flexibility and efficiency of lighting, as well as the expediency of creating various lighting scenarios in an educational environment. "Smart lighting" in the classroom should include automatic brightness control depending on the time of day and natural lighting, changing the color temperature of the light to create an optimal, comfortable atmosphere depending on the time of day, uniform lighting settings for each workplace, integration with other smart classroom systems. The purpose of this study is to study the influence of various lighting parameters (brightness, color temperature, dynamics) on cognitive functions, emotional state, on the level of concentration and academic performance of students; with this in mind, the creation of a prototype smart lighting system for the classroom, which will optimize energy consumption and create comfortable learning conditions.

Keywords: smart lighting, smart audience, digitalization, Internet of Things, biodynamic lighting, automation, control sensors, control system, voice assistant.

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ОҚУ БӨЛМЕСІНДЕГІ"АҚЫЛДЫ ЖАРЫҚТАНДЫРУ" ЖҮЙЕСІН ҚҰРУ

Аңдатпа

Білім беру үдерісіне инновациялық технологияларды енгізудің өзектілігі ұдайы өсіп келеді. Бүгінгі таңда "ақылды" жарықтандыру үйлер мен кеңселерде жиі қолданылады, алайда мектептер мен университеттерде сирек кездеседі. Оқу ғимараттары үшін дайын шешімдердің болмауы жарықтандырудың икемділігі мен тиімділігіне қойылатын нақты талаптармен, сондай-ақ білім беру ортасында әртүрлі жарық сценарийлерін құрудың орындылығымен түсіндіріледі. Оқу бөлмесіндегі "ақылды жарықтандыру" тәулік уақытына және табиғи жарықтандыруға байланысты жарықтылықты автоматты түрде реттеуді, тәулік уақытына байланысты оңтайлы, жайлы атмосфераны құру үшін жарықтың түс температурасын өзгертуді, әр жұмыс орны үшін жарықтандыруды біркелкі реттеуді, басқа ақылды сынып жүйелерімен интеграцияны қамтуы керек. Бұл зерттеудің мақсаты жарықтандырудың әртүрлі параметрлерінің (жарықтылық, түс температурасы, динамика) когнитивтік функцияларға, эмоционалдық күйге, оқушылардың зейіні мен үлгеріміне әсерін зерттеу болып табылады; осыны ескере отырып, энергия тұтынуды оңтайландыруға және оқуға қолайлы жағдай жасауға мүмкіндік беретін оқу бөлмесі үшін ақылды жарықтандыру жүйесінің прототипін жасау.

Түйін сөздер: ақылды жарықтандыру, ақылды аудитория, цифрландыру, Заттар интернеті, биодинамикалық жарықтандыру, автоматтандыру, басқару сенсорлары, басқару жүйесі, дауыстық көмекші.

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СОЗДАНИЕ СИСТЕМЫ «УМНОЕ ОСВЕЩЕНИЕ» В УЧЕБНОМ ПОМЕЩЕНИИ

Аннотация

Актуальность внедрения инновационных технологий в образовательный процесс неуклонно растет. Сегодня "умное" освещение все чаще встречается в домах и офисах, однако в школах и университетах оно пока редкость. Отсутствие готовых решений для учебных помещений объясняется

специфическими требованиями к гибкости и эффективности освещения, а также целесообразности создания различных световых сценариев в образовательной среде. «Умное освещение» в учебном помещении должно включать автоматическое регулирование яркости в зависимости от времени суток и естественного освещения, изменение цветовой температуры света для создания оптимальной, комфортной атмосферы в зависимости от времени суток, равномерную настройку освещения для каждого рабочего места, интеграцию с другими системами умного класса. Целью данного исследования является изучение влияния различных параметров освещения (яркость, цветовая температура, динамика) на когнитивные функции, эмоциональное состояние, на уровень концентрации внимания и успеваемость обучающихся; с учетом этого создание прототипа системы умного освещения для учебного помещения, который позволит оптимизировать энергопотребление и создать комфортные условия для обучения.

Ключевые слова: умное освещение, смарт аудитория, цифровизация, Интернет вещей, биодинамическое освещение, автоматизация, датчики управления, система управление, голосовой помощник.

Main provisions

Lighting plays an important role in the educational process. Properly selected lighting helps to increase students' concentration and improve their academic performance. The article discusses the issues of creating a "smart lighting" system that automatically adapts the light in the classroom to different conditions and needs of students. Based on the results of studying the influence of various lighting parameters on cognitive functions, emotional state, concentration level and academic performance of students, as part of the project assignment, students created a prototype of a smart lighting system for the classroom, which allows optimizing energy consumption and creating comfortable learning conditions. The created system uses light, motion and time sensors to automatically adjust the brightness of the light depending on the time of day, the level of natural light and the presence of people in the room, voice control.

Introduction

The modern world is actively implementing Internet of Things (IoT) technologies in all spheres of life. Every year these technologies become more accessible due to lower equipment costs and the rapid development of innovations. In the context of global digitalization, it is important to prepare the younger generation for a future where the use of IoT will be ubiquitous.

The educational system of the Republic of Kazakhstan has already taken steps in this direction. The computer science course in high school has a separate chapter dedicated to the Internet of Things. However, one chapter is not enough for the comprehensive development of IoT technologies. It is necessary to include them in the training of students through project activities, this is an excellent opportunity for students not only to master theoretical knowledge, but also to apply it in practice. One of the promising topics for IoT projects may be the development of "smart lighting" in classrooms, which will increase energy efficiency and improve comfortable learning conditions, which is an urgent task for modern educational institutions.

The concept of "smart lighting" is technically implemented in the context of a smart home, but classrooms have their own characteristics that must be taken into account when creating smart lighting. Lighting in classrooms plays a key role in creating a comfortable educational environment. Properly organized, adaptive lighting that changes brightness and color temperature depending on the time of day and type of activity helps to create optimal conditions for learning, reduces eye fatigue and increases concentration.

Traditional lighting systems in classrooms often do not take into account the specifics of the visual load of students and do not allow flexible adaptation of lighting to various types of activities and depending on the time of day. The purpose of this study is to study the influence of various lighting parameters on cognitive functions, emotional state, on the level of concentration and academic performance of students and, based on them, to create a prototype of a smart lighting system for the classroom, which will optimize energy consumption and create comfortable learning conditions.

Research methodology

The study was conducted in three stages: theoretical, experimental and analytical. The choice of research methods on each of them was determined by the goals and objectives of the study. At the first stage, the following theoretical research methods were used: the study and analysis of literature on the topic under consideration, as well as the analysis of existing solutions for the creation and application of smart lighting in classrooms. At the experimental stage, a survey of potential users was conducted to identify opinions on the feasibility of creating and implementing a smart lighting system in classrooms with automatic brightness and color temperature control depending on the time of day and type of activity in order to create comfortable learning conditions and improve the quality of student academic performance. The analysis of the results of the study made it possible to develop a conceptual model, determine the equipment and smart lighting control systems necessary for the implementation, and create a prototype of a smart lighting system for an educational facility based on them.

Results of the study

Light plays a key role in regulating our internal clock. Proper use of light allows you to maintain healthy circadian rhythms, improve sleep, improve mood and productivity. The physiology of human color perception is a fundamental area of research that studies the mechanisms of interaction of light stimuli with the visual system. Light, as a physical factor, has a significant effect on psychophysiological processes, modulating the emotional background, energy level and cognitive functions [1]. During the day (morning and evening hours), you can notice a decline in strength and a decrease in human energy. A similar emotional response to exposure to natural light appears under the influence of physical factors and appears in the body with the help of a hormonal (chemical) reaction. The control of biological clocks, seasonal and daily rhythms of the body all depend on the influence of natural light on hormones [1].

A lack of light exposure can cause depression, reduce performance and cause anxiety. At the same time, an optimally selected light mode can improve mood, reduce stress levels and improve concentration. Modern technologies, in particular, smart home systems and various IT solutions, actively use lighting effects to create personalized lighting scenarios that can adapt to human biorhythms, weather conditions and individual preferences. However, it should be borne in mind that prolonged exposure to certain spectral ranges, for example, blue light, can negatively affect eye health and disrupt circadian rhythms [2].

In 2002, scientists discovered a third type of light-sensitive cells in the retina of the eye, in addition to those responsible for twilight and color vision. These cells react to the illumination around them, although they themselves do not participate in the process of vision. They regulate biological processes in the body, such as hormone synthesis and visual reflexes, depending on the level of illumination [3]. The more natural light, the better for our health: it reduces the risk of depression, improves mood, increases energy levels, concentration and productivity. But, unfortunately, not all rooms have enough windows to provide the right amount of daylight.

The widespread use of lamps with electromagnetic controls in Kazakhstan, especially 4x18 W models with a mirrored grille, leads to a high level of light pulsation (38-49%). Such pulsation negatively affects the visual system, causing increased fatigue, especially in children under 14 years of age [4].

Biodynamic lighting comes to the rescue, which mimics the behavior of the sun and synchronizes with natural human biorhythms. It allows you to create a light close to natural in the room, adjusting not only the brightness, but also the color temperature of the light. Modern lighting systems are developed taking into account the influence of light on the emotional state of students. Biodynamic lighting helps both in studies and in recreation, changing its parameters depending on the time of day and human biorhythms (Figure 1). Research shows that during lessons, exams and tests, it is worth using light with a high color temperature (4 500 – 5 000 K), which stimulates the body by reducing melatonin levels and increases brain concentration and activity [5].

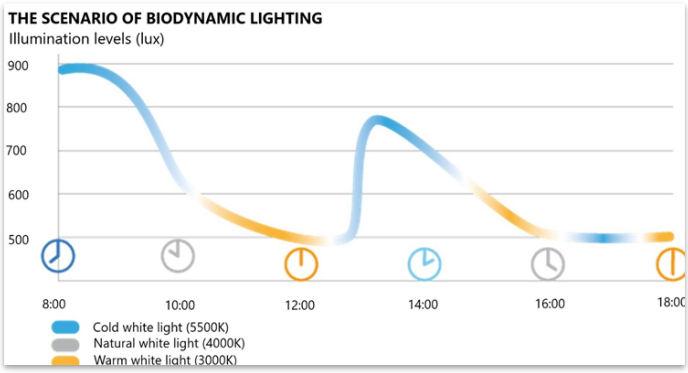

Figure 1. Biodynamic lighting scenario

Warmer light is recommended at recess and in the corridors (2 500 – 4 000 K) to help students relax and recuperate. Smart lighting, thanks to the use of biodynamic principles and modern technologies, creates optimal conditions for learning:

– Energy efficiency with significant energy savings due to intelligent lighting control.

– Adaptive lighting with automatic adjustment of brightness and color temperature depending on the time of day and type of activity, which helps to reduce visual load, increase student concentration and motivation, and improve the quality of learning.

In order to clarify the attitude towards the introduction of smart lighting in educational premises and to assess its effectiveness in comparison with traditional lighting systems, a survey of potential users was conducted. The survey was attended by school teachers, teachers and university students. In total, 50 people from the teaching staff and 150 students were interviewed (Table 1).

Table 1. Survey results

General awareness and opinion about smart lighting	*80% of teachers and 90% of students are familiar with the concept of "smart" lighting and understand its advantages*	*75% of teachers and 85% of students expressed the opinion that the use of smart lighting can significantly increase the comfort and efficiency of learning in classrooms*
The efficiency of smart lighting compared to traditional	*85% of teachers and 88% of students believe that smart lighting is much more effective than traditional lighting, as it adapts to natural lighting conditions and the intensity of classes*	*70% of teachers noted that smart lighting reduces eye fatigue and increases students' concentration during classes*
Features of the work of educational facilities	*65% of respondents pointed to the difficulties associated with the lack of ready-made solutions for the introduction of smart lighting in classrooms. The main reasons are the peculiarities of the use of premises: different modes of operation (lectures, seminars, laboratory work) require flexibility in light management*	*The teachers stressed that smart lighting should be integrated with building management systems for more accurate monitoring and analysis of the use of premises*
Analysis of the use of premises	*60% of teachers noted that classrooms often remain unlit or, conversely, overly illuminated, which negatively affects concentration and overall comfort*	*70% of the participants expressed the opinion that smart lighting can automatically adapt to the number of people in the room and current needs, which will improve the conditions for classes*

Despite the lack of ready-made solutions that take into account the specifics of classrooms, most teachers and students support the idea of switching to smart technologies. The survey results showed that 84% (42 out of 50) of teachers believe that smart lighting will significantly increase the comfort and efficiency of learning. Many noted that flexible adaptation of lighting to various types of educational activities will create more favorable conditions for the perception of information. One of the teachers stressed: "Smart lighting will create a more comfortable and stimulating learning atmosphere in the classroom." The students also appreciated the potential of smart lighting, noting that it will help reduce eye strain and increase concentration.

The smart lighting system for classrooms is an innovative solution that allows you to optimize lighting in classrooms and classrooms, creating a comfortable and effective learning environment. The system consists of LED lights, light, motion and presence sensors, as well as a central controller. Sensors collect information about the level of natural light, class occupancy, and time of day. The controller analyzes this data and transmits commands to the luminaires, adjusting the brightness and color temperature of the light.

The distribution of natural light in classrooms is often uneven: the maximum illumination is observed near windows - it is lighter closer to the window, and darker further away. Ordinary lamps are turned on for the entire audience, even if it is already light at the window. Standard artificial lighting systems do not take this feature into account, which leads to inefficient use of electricity. To solve this problem, you can install special sensors. They will measure how much light there is in each part of the room and automatically turn on or off the lamps. Installing sensors above each row of desks will allow you to maintain a set level of illumination in each area of the classroom, automatically adjusting the intensity of artificial lighting depending on the level of natural light. This approach will ensure uniform lighting of all workplaces and reduce energy consumption.

A voice assistant can be used to control the "smart lighting" in the classroom. To date, there are 3 voice assistants that understand Russian: Alice, Siri and Google Assistant (Table 2). When choosing an assistant, it is important to understand that not only the voice recognition system is selected, but also the devices and applications with which the control will take place.

Table 2. The main characteristics of popular voice assistants

Specifications	*ALICE*	*Siri*	*Google Assistant*
Voice recognition quality	*High*	*High*	*High*
Operating systems	*Microsoft Windows, Android, iOS и Linux*	*iOS, macOS*	*Android, iOS, Wear OS, Android Auto и Chrome OS*
Smartphone/ Tablet/ Laptop/ PC	*Any device*	*Apple Devices*	*Any device*
Unlocking your smartphone by voice	*No, it only works through the launch of the Yandex application (the exception is Yandex.Smartphone)*	*Yes*	*Yes*
Smart Speaker	*Yandex. Station*	*Apple HomePod (снята с производства)*	*Google Home*
Smart Watches	*Elari KidPhone 3G*	*Apple Watch*	*Android Wear*
Distinctive features	*Does not work with sensors*	*To access from the Internet, you will need to set up an additional Apple TV or iPad*	—

The basic voice commands for controlling the light are the same for all assistants – turn on/off the light and increase/decrease the brightness of the light. You can also use, for example, open/close blinds if they are equipped with an electric drive. The ALICE voice assistant dock station was chosen as a platform for the implementation of smart lighting in the framework of this study, due to its high flexibility and wide possibilities for the implementation of various projects (Figure 2).

Figure 2. Layout of the proposed lighting system in the classroom

For voice control of the light, you definitely need the Internet, a voice assistant and a connected smart room system. The voice assistant can be installed in any ordinary smartphone, tablet, laptop or computer, smart speaker. In general, there are many options. The operation of the system is carried out in this way (Figure 3):

- The user gives a command to perform a specific operation.
- The team is sent to the Yandex cloud.
- The system recognizes the command and transmits it to the cloud of the manufacturer of a particular device.
- Data is being transferred to the equipment.

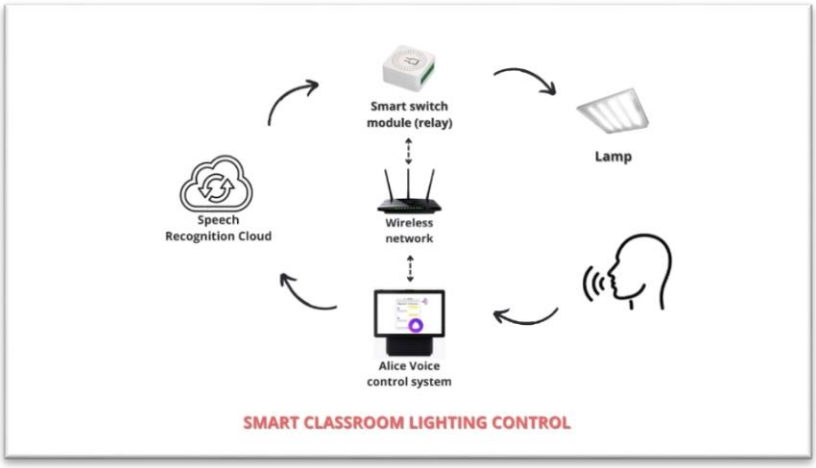

Figure 3. Intelligent lighting control in the classroom

Yandex Smart home management is provided through the Home with Alice app or by voice using a smart speaker. To set up the Yandex Smart Home, you need to download the Home with Alice app to your smartphone and create an account on the Yandex platform. After adding all the "smart"

devices, they can be controlled by voice. In addition to the "turn on" and "turn off" commands, more subtle settings are available: turn on the device for a certain time (or after some time), turn on a certain device mode. Using the application, you can not only turn on one of the devices, but also adjust its operation, create a schedule or work scenario for it, which is convenient for setting various lighting scenarios. And for a school project, you can use a microcontroller-based hardware platform designed for the development of smart devices and automated systems such as Arduino.

Like any programmable system, Arduino consists of:

- hardware – a printed circuit board with electronic components, connectors for connection, including USB type, as well as other circuits;
- the program part is called a "sketch" or a finished program.

For a school project, the Arduino smart lighting kit will include ready-made standard parts and components:

- Arduino Uno Controller;
- RTC DS3231 module – to get the current time;
- RGB LED or RGB ribbon for dynamic color change.

Connection pins:

- The RGB LED is connected to pin 2.
- The RTC DS3231 is connected via the I2C interface (SCL to A5, SDA to A4 on the Arduino Uno board).

The connection diagram of the smart lighting project is shown below, which changes the color of the light depending on the time is shown in Figure 4.

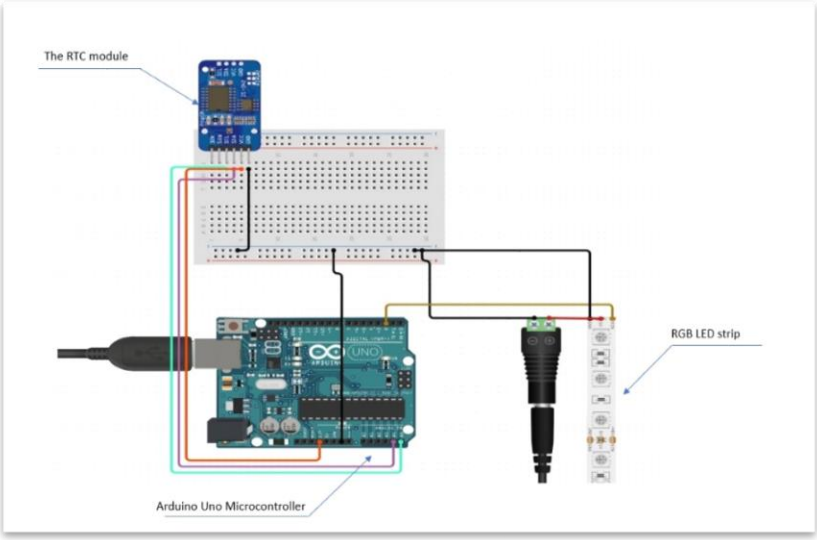

Figure 4. Connection diagram of the smart lighting project

Description of the program operation:

1. The DS3231 RTC module is used to get the current time. The program tracks the time in the clock and, depending on the time of day, changes the color of the lighting:
   - In the morning (6:00-12:00), a warm white light turns on.
   - in the afternoon (12:00-18:00) – cold white light.
   - in the evening (18:00-22:00) – warm orange light.
   - at night (22:00-6:00) – dimmed blue light.
2. An RGB LED or a NeoPixel-enabled ribbon changes its color depending on the current time.

Table 3 below shows the code of the smart lighting program, which changes color depending on the time of day.

Table 3. The program code

```
#include <Wire.h>
#include <RTClib.h>
#include <Adafruit_NeoPixel.h>

#define PIN 6
#define NUMPIXELS 1

RTC_DS3231 rtc;
Adafruit_NeoPixel pixels(NUMPIXELS, PIN, NEO_GRB + NEO_KHZ800);

void setup() {
  Serial.begin(9600);

  if (!rtc.begin()) {
    Serial.println("The RTC module was not found ");
    while (1);
  }
  if (rtc.lostPower()) {
    Serial.println("setting the time...");
    rtc.adjust(DateTime(F(__DATE__), F(__TIME__)));
  }
  pixels.begin();
}

void loop() {
  DateTime now = rtc.now();

  int hour = now.hour();
  if (hour >= 6 && hour < 12) {

    setLightColor(255, 223, 186);
  }
  else if (hour >= 12 && hour < 18) {

    setLightColor(173, 216, 230);
  }
  else if (hour >= 18 && hour < 22) {

    setLightColor(255, 153, 51);
  }
  else {
    setLightColor(0, 0, 139);
  }

  delay(1000);
}

void setLightColor(uint8_t r, uint8_t g, uint8_t b) {
  for (int i = 0; i < NUMPIXELS; i++) {
    pixels.setPixelColor(i, pixels.Color(r, g, b));
  }
  pixels.show();
}
```

Discussion

Smart lighting in the educational environment is a promising direction that allows you to create more comfortable and effective learning conditions. As part of this study, a prototype smart lighting system for the school classroom was successfully developed and tested. The system has demonstrated the ability to adapt the light level and color temperature of the lighting depending on the time of day,

the level of natural light and the tasks performed by the students. The developed system can serve as a basis for creating larger-scale solutions in the field of educational infrastructure.

Conclusion

When creating a smart lighting system in an educational institution, it is necessary to take into account many factors, ranging from regulatory requirements to the specific needs of students and teachers. It is important to choose reliable equipment, develop a competent project and ensure high-quality installation and configuration of the system. For middle and high school students, smart lighting projects can be not only an exciting activity, but also an excellent opportunity to deepen their knowledge in the field of electronics, programming and the Internet of things. The experience they gained during the implementation of the project can be useful in the development of other intelligent automation systems.

Acknowledgements

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