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Automated Analysis of Classroom Interaction Using IOT Sensors and Artificial Intelligence

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ABSTRACT

In modern education, the need for digital transformation of the classroom environment through the use of technologies such as the Internet of Things (IoT) and artificial intelligence (AI) is increasingly emphasized. This paper examines the potential of automated classroom interaction analysis using IoT sensors and AI systems to enhance teaching processes and monitor student attention and engagement. In addition to the theoretical review of the advantages and risks of these technologies, a survey is also conducted on students' attitudes towards the introduction of IoT/AI systems in teaching. The results show that while students recognize the benefits (personalization, objective monitoring, support for teachers), they express serious concerns about privacy issues, feelings of constant monitoring, and emotional stress. The paper proposes recommendations for the responsible and ethical application of smart classrooms, with a focus on data protection, transparency and user education.

1.   INTRODUCTION

Rapid technological advancement has significantly transformed various sectors of society, including education. Among the most influential technologies driving this transformation are the Internet of Things (IoT) and artificial intelligence (AI), which are increasingly integrated into educational environments to enhance teaching effectiveness and learning outcomes. IoT refers to a network of interconnected devices—such as sensors, cameras, and computing units—that collect and exchange data autonomously, while AI enables advanced data analysis, pattern recognition, and automated decision-making based on these data.

The integration of IoT and AI into educational settings has led to the emergence of so-called smart classrooms, where teaching and learning processes are supported by real-time data collection and intelligent analytics. In such environments, IoT sensors can capture various indicators of classroom activity, including noise levels, environmental conditions, participation patterns, and student attention. AI systems can then process these data to provide teachers with timely feedback and actionable insights, potentially improving classroom interaction, personalization of instruction, and overall learning efficiency.

The application of IoT and AI technologies in education offers several potential benefits. These technologies can support more interactive teaching methods, enable objective monitoring of student engagement, and assist teachers in identifying students who may require additional support. By relying on data-driven insights rather than solely on subjective observation, teachers may gain a more comprehensive understanding of classroom dynamics and student behavior. As a result, instructional strategies can be adjusted more effectively to meet diverse learning needs.

Despite these advantages, the implementation of IoT and AI in classrooms also raises significant challenges, particularly in relation to privacy, ethics, and psychological well-being. The continuous collection and analysis of data—especially audio-visual and behavioral data—may lead to concerns about excessive monitoring, loss of autonomy, and emotional discomfort among students. These concerns are especially critical in educational contexts, where learners are often minors or young adults, and where trust and a sense of safety are essential for effective learning.

Furthermore, legal and regulatory frameworks governing the use of AI and IoT in classroom-level education remain underdeveloped in many regions. While general data protection regulations exist, they often do not provide sufficiently detailed guidance on the ethical use of real-time monitoring technologies in educational environments. This regulatory uncertainty can hinder responsible implementation and increase the risk of misuse or misinterpretation of collected data.

In this context, the present study aims to examine the potential of IoT sensors and AI systems for automated analysis of classroom interaction, while critically addressing the ethical, legal, and psychological implications of their use. Specifically, the study investigates students' attitudes toward AI-based classroom monitoring, focusing on perceived benefits, concerns, and emotional responses. By combining a review of relevant literature with empirical data from a student survey, this paper seeks to contribute to a more balanced and responsible understanding of smart classroom technologies and their role in contemporary education.

2. RESEARCH PROBLEM

Traditional teaching faces limitations in terms of **monitoring student interaction and engagement**. It is difficult for teachers to simultaneously track all the discussions, the attention level of each student, and other subtle indicators of interaction during class. There are often unused opportunities for **timely intervention** – e.g. to notice a student whose concentration is declining or those who are less likely to engage in discussion. At the same time, modern students

are growing up with technology and there is an expectation that the teaching process will be modernized to make it more interactive and efficient. This is where the idea of using IoT devices (such as smart cameras, microphones, wearable sensors) and AI systems that would **automatically collect data** about events in the classroom and analyze them in real time. This approach could provide detailed insights into classroom interaction, including who asks questions, how long individuals speak, levels of student attention, and the overall classroom atmosphere. Figure 1 shows a representative example of a smart sensor system for the classroom. This system includes sensors to collect data in multiple ways, such as cameras, temperature and thermal sensors, light sensors, air quality sensors, personnel recognition cameras, sound level meters, etc., which can record human behavior and environmental characteristics as reference data and opinions to create a good learning experience.
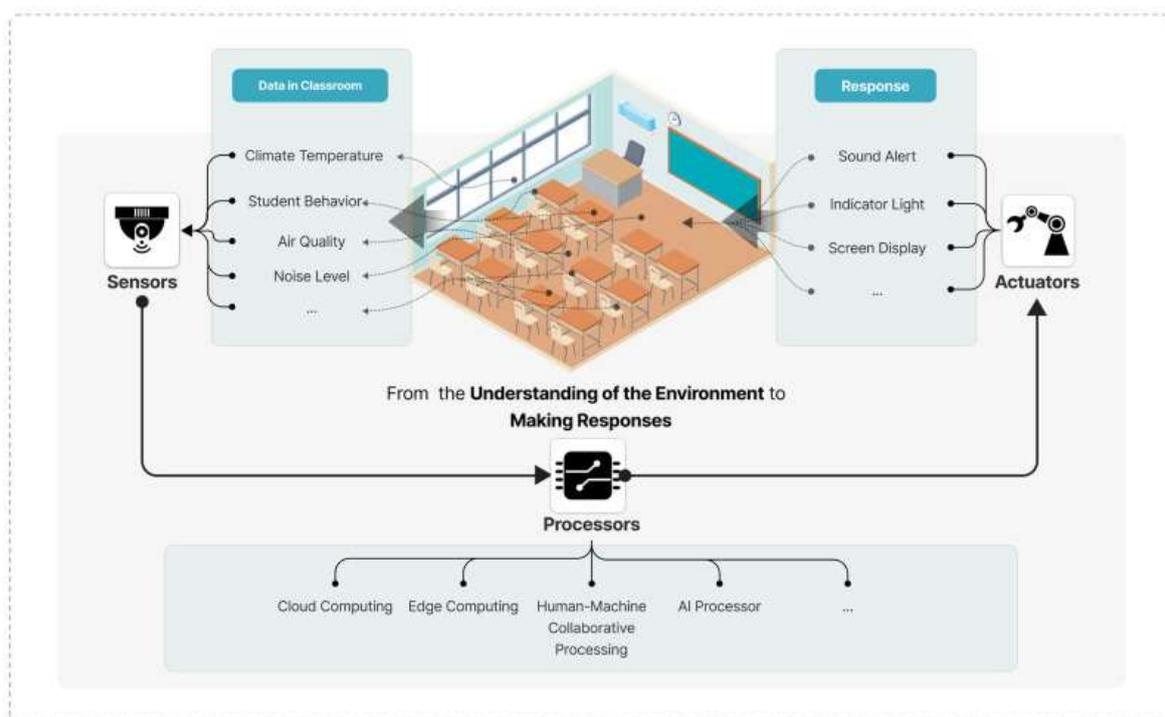
Figure 1: Example of a smart sensor system in the classroom. Source: https://tinyurl.com/2jzhtt9z

The problem arises when trying to implement these technologies in a real educational environment. Although technically feasible, the question arises **as to whether such supervision is acceptable** by the participants themselves. Past experience suggests that the introduction of constant audio-visual monitoring can cause resistance – primarily due to the feeling of invasion of privacy and the stress of knowing that every movement or word is being monitored. In other words, there is **a gap between the potential of the technology and the trust of users** in that technology. In addition, the legal framework for this is not fully defined: schools and colleges do not always have clear data protection and privacy protocols when it comes to IoT/AI solutions, which causes uncertainty and the risk of data misuse.

In short, the problem addressed by the research can be formulated as follows: How to introduce

IoT sensors and AI into the classroom in an efficient and ethically acceptable way for automated interaction analysis, while preserving the privacy and well-being of students? These issues include technical aspects (system integration, accuracy and reliability of collected data), pedagogical aspects (impact on the teaching process, acceptability by teachers and students) and legal and ethical aspects (regulation of data collection and use, consent and transparency). Identifying and understanding these challenges is crucial for further steps in the development *of smart classrooms* and is the focus of this research.

3.   RESEARCH OBJECTIVES

The overall objective of this paper is to examine the role and capabilities **of IoT and AI technologies in improving classroom interaction**, and to determine the advantages, disadvantages and challenges of implementing such systems in the educational environment. with   the **requirements of pedagogical practice and ethics**. The paper provides an integrated analysis of the technological aspects of smart classrooms and users' responses to such innovations, contributing to a better understanding of how technological advancement can be aligned with pedagogical practice and ethical considerations.

Specific objectives include:
*   **Overview of concepts and literature:** To present the theoretical foundations of the Internet of Things and artificial intelligence relevant to education, including definitions, current trends, and examples of application in teaching. Through literature review, identify already existing *smart classrooms* or similar projects and what can be learned from them about the impact on classroom interaction.

*   **Benefit and risk analysis:** Explore the potential **benefits** that IoT/AI brings to teachers and students (e.g. personalization of learning, objective monitoring of progress, greater involvement of all students), but also **risks** (e.g. invasion of privacy, possibility of algorithm bias, technical problems, digital divide)[10]. In particular, consider ethical and legal issues, as well as the psychological impact of continuous monitoring technology on students.

*   **Empirical examination of student attitudes:** Conduct a survey among students to determine **how they perceive the idea of IoT/AI monitoring in the classroom**. More specifically, find out how acceptable it is to install AI-connected microphones and cameras in the classroom, what benefits students recognize and what worries them the most, and what emotion (discomfort or pleasure) is caused by the thought that they are accompanied by such a system.

*   **Analysis and interpretation of findings:** Analyze survey results to gain insight into the **level of acceptability of**   these technologies and the main factors influencing a positive or negative attitude. Compare the findings with the expected benefits and risks from the literature – e.g., whether students cite the same things that the literature emphasizes as advantages, and whether they are most concerned about privacy as ethical papers suggest.

- **Formulating recommendations:** Based on the theoretical and empirical part, offer concrete **recommendations** for the successful and responsible application of IoT sensors and AI in education. This includes guidance on how to address the concerns identified (privacy, transparency, regulation) and how to increase the acceptability of new technologies among students and teachers. Also, identify areas where additional training or information is needed, as well as what steps institutions need to take before introducing such systems into classrooms.

4. LITERATURE REVIEW

There is significant relevant literature that provides theoretical assumptions and previous research related to the Internet of Things and artificial intelligence in education, with particular emphasis on classroom interaction and ethical implications. The literature review includes the definition of the terms IoT and AI, the presentation **of examples of the application of** these technologies in the educational context, and insight into the current knowledge about their effects, as well as the challenges they bring.

The Internet of Things (IoT) in education. IoT, as stated, refers to a wide network of "connected things" – devices equipped with sensors and communication modules that collect data from the environment and exchange it over the Internet. Popular examples from everyday life are smart home devices (thermostats, lighting, security cameras) that can be remotely monitored and controlled. In education, IoT is the foundation of the concept of **the "smart classroom"** – a modern learning environment in which lectures and infrastructure are supported by digital devices that communicate with each other. The smart classroom is equipped with various sensors and devices: e.g. presence recognition cameras, microphones and audio sensors for measuring noise levels, smart boards, sensors of ambient conditions (temperature, lighting, air quality) and wearable devices or RFID tags for attendance monitoring. All these elements create a network that **monitors different aspects in real time**.

The application of IoT in schools and colleges is already showing certain benefits. IoT devices enable **automatic collection** of teaching data: e.g. systems can automatically record the presence of students via RFID cards or biometrics, monitor environmental conditions and adjust lighting and temperature if necessary for a more comfortable environment, and even monitor the use of teaching materials or the movement of students in space to optimize schedules. The literature points out that the use of IoT technologies can create **a more informative and interactive learning environment**, in which the teacher receives a rich dataset to understand student progress. So King and sar. (2024) state that IoT provides an opportunity for teachers to improve **the monitoring of learning pace and student difficulties** , which in the long run allows for personalization of teaching (e.g. additional support for those who need it). Also, Aldowah et al. (2017) point out that the future of education is focused on adapting teaching to the requirements of future professions through IoT technologies – which implies that students will learn through practical work with devices, acquire interdisciplinary knowledge about electronics, programming and data analysis, as well as develop digital competencies needed for the modern labor market.

However, the mass integration of IoT devices also brings serious challenges. One of the main concerns in the literature is **data security and privacy**: any networked device is a potential point of attack or unauthorized access to data. In the context of schools, sensitive student data (e.g. classroom recordings, biometrics or activity data) must be protected from misuse. King and Sar. (2024) note that governments and the technology industry are increasingly aware of these risks, and efforts are being made to **protect the end users of IoT systems through standards and policies.** Another problem is **the lack of standardization and interoperability** – different devices and platforms must work together reliably; otherwise, implementation in practice can be technically difficult and expensive (e.g. integration of multiple sensors from different manufacturers). Also, **financial costs** can be significant for schools: the acquisition and maintenance of a smart classroom requires investments in equipment, network infrastructure and staff training, which is not available to every institution.

Artificial intelligence in education is increasingly used in the education sector, from intelligent tutors and personalized learning systems, to learning analytics and administrative procedures. In the context of the classroom, AI systems can process data collected by IoT sensors to provide **deeper insights**: machine learning algorithms are capable of recognizing patterns in student behavior, predicting when interest wanes, or detecting what types of tasks are causing[8] difficulties. One systematic literature review (Fütterer et al., 2025) found that the bulk of AI classroom management tools have the purpose **of tracking students' attention, behavior, or engagement** during class. Examples include computer vision systems that analyze students' facial expressions and gaze to assess whether an individual is following a lecture, or networks of microphones that monitor the frequency and tone of student responses. The data obtained in this way can offer the teacher **an objective metric of the** atmosphere in the classroom or the progress of the group. AI can also **automate routine tasks** – e.g. counting attendees, reviewing homework with the help of intelligent algorithms, and even giving basic feedback to students on frequently asked questions, saving teachers time for more creative activities.

The benefits of AI in education are significant: personalization of teaching is one of the most prominent benefits. A system that learns each student's habits and needs can recommend customized materials, pace of work, or additional exercises to those who need them. Also, the analysis **of large amounts of data** (e.g. test scores, interactions on learning platforms) can help institutions improve curriculum or provide support to learners. However, in addition to the benefits, experts warn of more risks of **AI** in the educational environment:

- **Bias and fairness:** Algorithms learn from data that may contain biases. If student data is incomplete or biased, AI systems could favor or discriminate against some students. For example, an interaction analysis system trained mainly on extroverted communication models could misjudge more introverted students as "uninterested." This can lead to deepening stereotypes or unequal treatment of students. It is therefore important to ensure that **AI coaching** encompasses a variety of scenarios and that the results it produces are critically evaluated by teachers.

- **Lack of transparency:** Often, AI models are **"black box"** – they make decisions or

recommendations, but it's not clear on what basis. In education, this raises the question of responsibility: if AI misidentifies a student as inattentive, who is responsible for the consequences? Uncertainty about how AI comes to conclusions can diminish teachers' and students' trust in the system. This is why research insists on *explainable artificial intelligence (XAI)* in school-based applications, so that users can understand why something was recommended to them or how a certain engagement score came about.

- **Privacy and data protection:** AI systems generally need large sets of data about students (from interaction patterns to personal data) to function effectively. This raises the question of **who collects and stores this data, and who has access to it**. The collection of audio/video recordings from the classroom or biometric indicators (e.g. facial expressions, heart rate) is particularly sensitive – such data falls within the domain of student privacy. Research warns that children's data is often collected and processed **without sufficient knowledge or consent of** parents and students themselves, which is a serious ethical failure. Therefore, a clear legal framework and consent protocols are required before the introduction of such technologies.

- **Over-reliance on technology:** Another risk is a scenario where teachers and students rely too much on AI, so they begin to neglect their own critical thinking or communication skills. If, hypothetically, an AI system were always "leading" a class discussion or providing answers, students could participate more passively, feeling that the technology would do it for them. In the long run, **excessive automation** can harm the development of key skills in students. That is why educators point out that AI should be *a tool* that supports interaction, and not a substitute for the human component of teaching.

- **Legal and regulatory vacuum:** Technology is often advancing faster than regulations. In many countries (including our region), **there are no specific guidelines or laws** governing the use of AI in micro-level (classroom) education. There are general laws on the protection of personal data (e.g. GDPR in the EU), but specific provisions on how to handle student data generated by AI analysis in the classroom are generally not worked out[7]. This creates uncertainty for educational institutions that would like to introduce these innovations – how to legally dispose of the collected data, how long to keep it, whether they are allowed to share it with third parties (e.g. a technology supplier) and the like. The literature emphasizes the need to develop **codes of ethics and rules** for AI in the classroom as soon as possible, in order to prevent potential harmful impacts and protect students as a vulnerable population.

The literature review indicates that the concept of smart classrooms, supported by IoT and AI technologies, is rapidly evolving and attracting high expectations. On the one hand, existing research demonstrates that sensors and algorithms can positively impact education by improving learning conditions, increasing student engagement, and enabling personalized instruction. For example, Huang and sar. (2024) in their systematic review, they show a multitude of sensors used to monitor various aspects of the classroom (physical and behavioral data) and point out that the combination of sensors with AI allows **for more efficient data processing and expanded** real-time analysis capabilities. On the other hand, **ethical discourse** catches up: Fütterer et al. (2025)

point out that less than a quarter of the available studies have discussed the ethical implications of AI in the classroom at all, meaning that not enough attention has been given to this aspect[1]. This fact underscores the risk that the technology will be implemented before issues such as data privacy and security have been addressed. For sustainable progress, it is necessary **to balance technological innovation with ethical responsibility** – this balancing act is the central motive of this research.

5.   RESEARCH METHODOLOGY

Research design: For the purposes of this paper, a combined methodological approach was applied. The first part of the research is based on **literature analysis and theoretical considerations** – relevant books, articles and reports on IoT and AI in education were collected and studied, in order to build a theoretical framework and identify the main topics (benefits, challenges, ethical issues). The second part includes **empirical research** through a questionnaire, which collected quantitative and qualitative data on students' attitudes. This design (known as *mixed-methods* in a broad sense) allows theoretical insights to be linked to the actual perceptions of technology users, thus obtaining a complete picture of the problem.

Participants and sample: The survey was conducted among students of a higher education institution in Bosnia and Herzegovina (students of different years of study, aged from ~18 to over 24 years). A total of **80** students participated in the survey. A convenience sample was used, with students participating voluntarily through an online platform after being informed about the purpose of the study. Anonymity was guaranteed, so that the respondents felt free to express their honest opinion. The sample includes students of both genders and different fields of study, which allows for diverse perspectives. There were no specific exclusion criteria except that the respondent was a current student (all participants were familiar with the basic concepts of modern technology in education).

• Instrument: The research was conducted through an online questionnaire created specifically for this study (using the Google Forms platform). The questionnaire consisted of a total of 15 questions (of which several demographic and several key thematic questions). The structure of the questionnaire included: - Demographic issues: age (categorized: e.g. 18-20, 21-23, 24 and above) and study status (year of study, faculty – optional). This was used for basic statistical processing and checking the diversity of the sample.

• Attitude on the acceptability of IoT/AI monitoring: the key question for students is "How acceptable is it for you to have microphones and cameras installed in the classroom connected to an AI system that monitors who speaks how much and how closely follows the lessons?". The answers are given on a Likert scale in 5 options: Fully acceptable, Partially acceptable, Neutral, Unacceptable, Completely unacceptable. This question aims to quantify the general attitude of students towards the concept of a "smart classroom" with audio-visual monitoring.

• Perceived benefits of technology: One of the questions was "What do you think are the

biggest benefits of using this technology?" with the multiple-choice options offered: (a) It helps to include all students evenly, (b) It allows teachers to better understand the dynamics of the class, (c) It helps to monitor students' attention during class, (d) It increases the effectiveness of teaching. Respondents were able to mark one or more of the benefits they considered relevant. The goal is to identify what students see as potential gains from IoT/AI systems in the classroom.

- Perceived flaws/concerns: Also significant is the question "What concerns do you have about this technology?" with the options offered: (a) Violation of privacy and sense of monitoring, (b) Possibility of technical errors and inaccurate assessments, (c) Possible stress and discomfort due to monitoring, (d) Dependence of teaching on technology. Respondents were also able to choose multiple answers. This section directly examines the negative aspects and fears that students associate with IoT/AI in the classroom.

- Emotional reaction to follow-up: the last key question examined the student's feeling about the auto-monitoring scenario: "How would you feel if your speech and attention in the classroom were automatically monitored and analyzed by AI through microphones and cameras?". 4 options are offered: Pleasant, Neutral, Uncomfortable, Very uncomfortable. This question measures the subjective experience – the level of (un)pleasantness – at the thought that technology follows their work in class. This complements the previous question of acceptability: it is possible that someone considers the technology acceptable in principle, but still feels a certain discomfort, and vice versa.

Data collection procedure: The questionnaire was distributed electronically – the access link was sent to students via e-mail and student social networks with a brief explanation of the purpose of the research. In the introduction to the survey, it was emphasized that the research is anonymous and voluntary, and that the data will be used exclusively for scientific purposes. The survey was open for two weeks, during which a sufficient number of responses for analysis was collected (N = 67). All responses are automatically recorded in an electronic database (Google Forms spreadsheet), which facilitates further statistical processing.

Data processing and analysis: The data were analyzed using descriptive statistics and qualitative analysis of open-ended responses, with primary emphasis placed on quantitative indicators derived from closed-ended questions. For each question, the percentages of answers were calculated. For example, for the question about the acceptability of technology, it is determined what percentage of students make up each of the 5 categories (fully acceptable, partially, etc.). Similar distributions are made for the feeling (emotion) of tracking. Questions about benefits and concerns were analyzed by frequency of choice – it was identified which options were **most often** chosen by respondents (indicating the most prominent advantages and most common concerns). The results are presented in tabular and graphical form for easier interpretation – e.g. **a chart** showing the proportion of students who consider the technology acceptable or unacceptable, and **a table** summarizing the ranked benefits and risks according to the frequency of selection.

Note on validity and reliability: Given that this is a questionnaire created for this purpose,

special attention was paid to the clarity of the questions so that all respondents could clearly understand the terms. Pilot testing of the questionnaire was conducted on a small group (a few students) before the official data collection, which helped to eliminate any ambiguities and confirm that the questions measure what was intended (content validity). The reliability of the scale (Likert Acceptability Scale) was checked by a rough assessment of internal consistency – although it is a single question with 5 options (so the classic confidence coefficient is not applicable), a pairing was made with a question about the feeling of discomfort to see if the results were consistently moving (which was confirmed – students who stated that the concept was unacceptable to them mostly felt uncomfortable due to monitoring, which shows the logical consistency of the answer). In data processing, software for spreadsheet calculations (Excel/Google Sheets) and the SPSS statistical package for calculating basic statistics were used. This methodological approach has enabled us to obtain reliable and relevant data on students' attitudes that can be further compared with theoretical assumptions from the literature. By combining quantitative results and qualitative insights, a rich basis for interpretation in **the discussion of the results** is provided.

6. ANALYSIS OF RESEARCH RESULTS

The results of the survey research on students' attitudes, with parallel connection with the expectations formed on the basis of literature review, are presented through quantitative findings (percentages of answers to key questions) and supported by a narrative description of the most important observations. Graphical representations are also included to illustrate distribution trends.

Acceptability of IoT/AI Classroom Monitoring. When asked about the general acceptability of setting up AI-connected IoT sensors (microphones, cameras) to monitor the flow of interaction in class, students' answers were divided, but with a clear trend towards skepticism. **Graph 1** shows the percentage of responses on a scale from "completely acceptable" to "completely unacceptable". Only a minority of respondents (10.44%) considered such a system to be completely acceptable. This group of students generally believes that technological innovation is welcome and fully **believes** in its purpose. A slightly larger part of 20.90% chose the option *partially acceptable*, signaling moderate optimism with some reservations. **The largest segment of respondents classified technology in less acceptable categories**: roughly, more than half of students consider the installation of such devices *unacceptable* or *completely unacceptable*. The rest took a neutral stance.
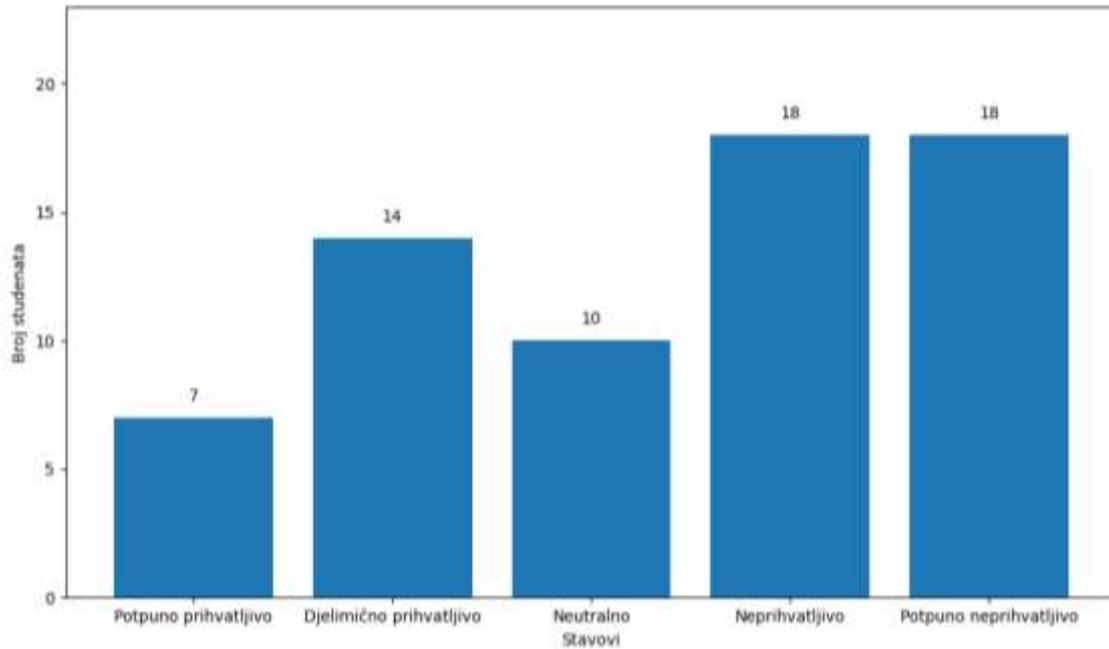
Chart 1. Students' Attitudes on the Acceptability of IoT/AI Classroom Monitoring

These findings indicate a prevailing reluctance toward automated classroom monitoring, largely driven by concerns related to privacy and psychological discomfort among students. Although there is an enthusiastic minority, a significant proportion are cautious or negative – indicating potential barriers to implementation if such a system were to be introduced. (The exact percentages per category can be found in Table 1, but in general it can be said that **Approximately two-thirds of respondents are at least partially opposed to** the introduction of IoT/AI monitoring in their classroom.

Table 1: Students' Attitudes on the Acceptability of IoT/AI Tracking in the Classroom

Red. No.	Status	Number of students	Percentage (%)
1	Fully acceptable	7	10,4
2	It's partially acceptable	14	20,9
3	Neutral	10	14,9
4	Unacceptable	18	26,9
5	Totally unacceptable	18	26,9

Perceived advantages of technology. The questionnaire offered respondents a list of possible **benefits** of using IoT/AI systems in teaching, asking them to mark those they recognized. The results are summarized in **Table 2**, which shows each advantage offered and the percentage of students who chose it as significant.

Table 2: Recognized benefits of IoT/AI technology

Red. No.	Recognize the benefits	Number of students	Percentage (%)
1	Gives teachers a better insight into class dynamics	49	73,1
2	Helps to include all students evenly	44	65,7
3	Helps to monitor the student's attention during the lesson.	41	61,2
4	Increases efficiency	29	43,3

Several conclusions can be drawn from the answer:

• Most respondents (the majority) recognize that this technology would **allow teachers to have a better insight into the dynamics of the class**. About 73.1% of students marked this item, suggesting that even skeptical students see value in the teacher having **objective data** about who is participating and how attentive they are, rather than relying solely on subjective impression. This result is consistent with claims in the literature that IoT/AI can help teachers *better track students' progress and difficulties*.

• A significant number of respondents (65.7%) stated that the system **helps to include all students evenly as an advantage**. This perception is significant: students believe that technology could prevent situations where only the loudest participants dominate the class. If the AI keeps track of who is talking how much, the teacher can more easily spot those who are not answering and try to activate them. About as often the advantage that the system **helps monitor students' attention during classes** is mentioned – which is understandable because this is one of the important functionalities of smart classrooms (e.g. detecting whether students are following the lecture or are distracted).

• The advantage *"Increases the efficiency of teaching"* was chosen somewhat less often compared to the others. This may mean that students are unsure of how exactly efficiency would be increased (because efficiency is more of an indirect outcome of better dynamics and attention). However, a significant proportion (43.3%) see this as a benefit, probably in terms of saving time on administrative tasks (such as attendance records, activity evaluation) that technology can automate.

Basically, **students have identified more potential benefits** of IoT/AI in the classroom: primarily a better informed and fairer teaching process (the teacher has more information and can involve everyone more equally). These findings are encouraging because they show that even among those who are cautious, there is an understanding of what the positive side of technology might be. In qualitative comments, some students stated that *"technology itself doesn't worry them if it brings something good, but it all depends on how it's used,"* further illustrating this balance between recognizing benefits and hesitating about potential problems.

The biggest concerns and fears. As for the **negative aspects**, the results are very clear and somewhat uniform. Students almost unanimously pointed to **privacy violations and a sense of constant monitoring** as the main concerns related to the introduction of such technology – this option was marked by the **vast majority of respondents**. As expected, this issue of privacy is at the heart of the resistance: the idea of having their every movement, speech, or facial expression recorded and analyzed makes students feel uncomfortable, as if under a magnifying glass. This finding is consistent with existing literature that identifies privacy as a central ethical concern in the use of AI systems in education.

Another common concern is related to **possible stress and discomfort due to monitoring**. More than half of the students emphasized that learning about continuous monitoring would also burden them psychologically – they would probably be more nervous while answering or discussing, knowing that they are "watching" not only the teacher but also **an invisible algorithm**. Some have noted in the comments that this could lead to **self-censorship** or avoiding interaction ("I'd feel like I'm on a reality show, so I'd talk less", a free quote from one response), which is paradoxically the opposite of the desired effect (which is to get everyone more involved). These answers emphasize the importance of the emotional aspect – the technology that is supposed to motivate interaction could, if not accepted, have *the opposite effect.*

A third significant concern is the **reliability and accuracy of the system** – "the possibility of technical errors and inaccurate estimates" was also among the more frequently chosen options. Students are not only concerned *about what* is being done with the data, but also *whether the data is correct*. There is a fear that the system might misinterpret someone's silence as a lack of attention (perhaps the person is attentive but introverted), or that technical problems could lead to misinformation to the teacher. This concern is rational – if a teacher blindly trusts AI and AI makes a mistake, the consequences can be unfair to the student. Such scenarios contribute to mistrust: **students do not want to be evaluated by non-transparent technology** that they are not sure how it works. This finding resonates with academic warnings about the dangers of over-reliance on AI without human verification.

Lastly, **the dependence of teaching on technology** has also emerged as a concern, albeit somewhat less frequently than privacy and stress. A number of students expressed fears that the introduction of such systems would make teaching too technologically mediated, meaning that the quality of lessons could suffer if technology fails, or that teachers could leave too much of a role to technology (instead *of making an effort* to interact themselves). This concern leans into the broader discourse that technology should be an aid rather than a substitute for pedagogical efforts. Interestingly, it was more often cited by students of technology majors, which suggests that even those who love technology see a problem if **the purpose of teaching is subordinated to gadgets**.

Feeling (un)comfortable at the thought of automated tracking. In addition to the questions about eligibility, the students also rated how they would feel if they were really **under such supervision** in class. The results are somewhat expected given the previous answers: **the majority of respondents stated that they would feel uncomfortable** or very uncomfortable in such a

situation. In particular, about 40.3% chose "uncomfortable" and an additional 35.8% chose "very uncomfortable" Chart 2 illustrates the relationship between pleasant and unpleasant feelings. A smaller fraction of 19.4% said they would feel neutral, while a very small percentage of 4.5% said they would be comfortable being monitored.
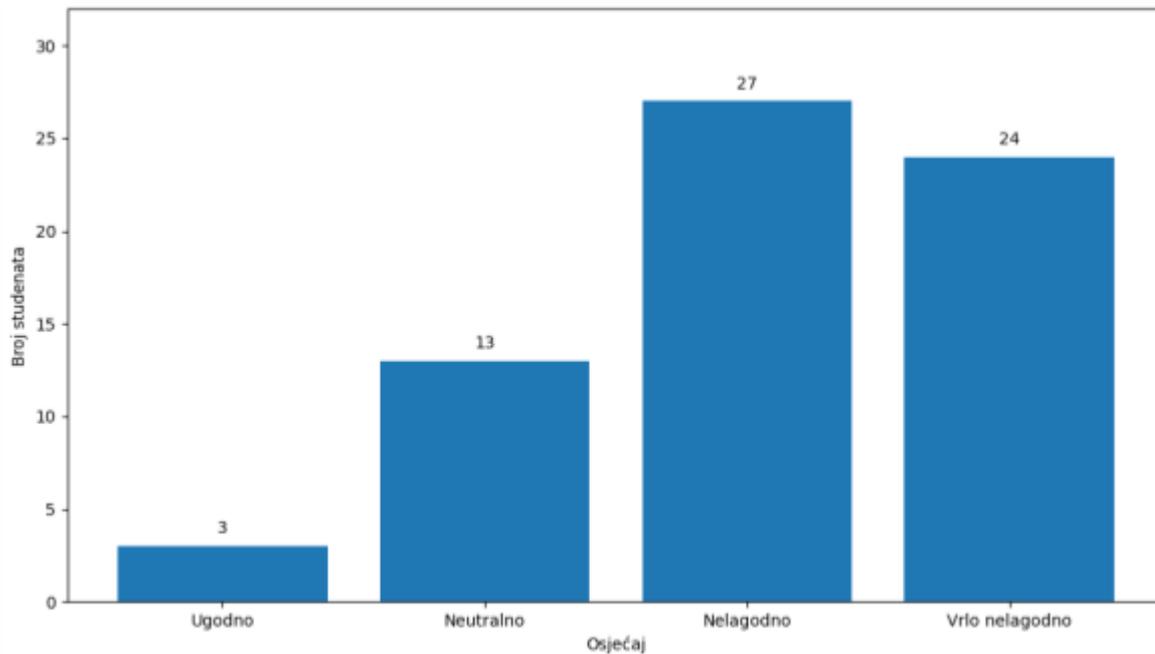
Chart 2: Students' Emotional Reaction to the Idea of Automated Tracking

These data strongly highlight the **psychological pressure** that the concept of a supervised environment creates among students. Even some who labeled the technology partially acceptable, admitted that they would subjectively be nervous or uncomfortable knowing that their every action was being recorded. This is a key point for the creators of such systems: **the perception of monitoring can create stress** that potentially diminishes the benefits of the system. In other words, if students begin to change their behavior due to discomfort (e.g., to show up less, or to act like false attention), then the data collected by the system no longer reflects the authentic interaction – thus losing the meaning of the whole endeavor. This phenomenon is similar *to the Hawthorne effect* in research (subjects change their behavior when they know they are being watched).

Overall, the research findings point to **a twofold picture**: students see certain **objective benefits** and generally admit that IoT/AI in the classroom *can* bring improvements, but their **emotional reaction and concern at** this point is stronger than enthusiasm. The greatest burden lies on the issues of privacy and a sense of freedom in the classroom – without addressing these issues, acceptability remains low. At the same time, the fact that a good part of students still recognize the benefits provides a basis for optimism: with the right approach (e.g. assurance that privacy will be protected, gradual introduction of the system, education about the purpose), there is room for their attitude to improve over time.

7.   CONCLUSION

Summary of findings. The results of the theoretical review and empirical research consistently point to the enormous **potential, but also the challenges of** applying IoT sensors and AI in the educational environment. On the technological side, it is clear that modern **IoT devices and artificial intelligence algorithms can provide unprecedented insight** into what is happening in the classroom: automated interaction analysis makes it possible to record quantitative indicators (such as the number of interactions per student, duration of exposure, noise level or attention) that can help the teacher to look at the activities in class more objectively. This can further improve the teaching process – teachers can more quickly identify which students need to be more involved, which topics cause attention or misunderstanding, and generally **adapt their** method of working based on real-time data. Also, IoT/AI solutions can take over routine tasks (such as attendance records or speech timing), leaving teachers more room to focus on student interaction and creative lesson planning.

On the other hand, the perception and acceptability of these technologies among end users – students – is currently not at a high level. Our respondents expressed significant **concerns about invasions of privacy and a sense of constant surveillance**, which is in line with global ethical views on the introduction of AI in classrooms. The majority of students in the survey stated that they would feel uncomfortable if they knew that their voice and movements were continuously monitored by algorithms. This resistance is not unfounded – it comes from the fear that such supervision would change the nature of the classroom atmosphere, potentially making it less **spontaneous and open**, and more controlled and stressful. Also, trust questions were raised: can it be trusted that the data will be used exclusively for educational purposes, that there will be no misuse or leakage of information, and will the interpretation of this data by AI be correct and without bias?

Response to the research problem and goals. The central problem of the paper was how to introduce IoT and AI into the classroom in an acceptable and ethical way. The research has shown that **the technological solution is only part of the equation** – how this solution is presented and implemented in the pedagogical context *is equally important* . The goals of the paper were to explore opportunities and challenges: opportunities were confirmed through literature and recognized by students (more effective monitoring, better involvement, personalization), while the challenges clearly emerged through the topic of privacy, psychological comfort and regulatory concerns. The paper also aimed to examine the attitudes of students – in short, these attitudes are *reserved*, although not entirely negative. Students are aware of both the good and the bad sides, but until the bad sides are addressed, **most are not ready** to accept such an innovation in their daily teaching.

Implications for educational practice. The findings of this research indicate that educational institutions and policymakers need to approach the introduction of IoT/AI technologies carefully and inclusively. Technology should serve as a tool that **empowers teachers and students**, not as a means of control or pressure. Before implementation, not only the technological infrastructure should be provided, but also **the ethical framework** and education of all participants about what

the system does and why. Otherwise, we risk that good intentions will be misunderstood and rejected by those for whom they are intended.

Research limitations and suggestions for future research. It is important to note that this study was conducted on a limited sample of students from one institution, and the findings cannot be fully generalized to the general population without caution. It is possible that, for example, primary and secondary school students would react differently (perhaps even more pronounced to the issue of supervision, given their age). Additionally, this study examines declarative attitudes; the real test of acceptability would require practical classroom implementation, where it would be seen how attitudes may change through experience. Therefore, future research could include **smart classroom pilot projects**, followed by qualitative research (e.g. focus groups with students and teachers) to gain deeper insights into the experience of such an environment. Also, it is recommended to compare the perspective of students with that of teachers: while students care about privacy, teachers may have different concerns or expectations (e.g., whether technology makes their job easier or more difficult).

The findings suggest that **IoT and AI have great prospects of entering the education system** and holds promise to improve the quality of teaching. However, **the pace and manner of this entry** must be carefully planned. Technology must be accepted by the community to fulfill its purpose. The work has shown that with the implementation of appropriate measures, there is a path to integrating these tools into the classroom in a way that will maintain the trust and safety of all participants. This will enable a balanced realization of the benefits of innovation, while minimizing its side effects – which can really make the educational process **smarter, but still humanized**.

8.   RECOMMENDATIONS

Based on the research conducted and considerations within this paper, a number of recommendations stand out for educational institutions, policy makers and researchers dealing with the application of IoT and AI technologies in the classroom. The aim of these recommendations is to facilitate the successful and ethical implementation of automated analysis of interaction in teaching, with high respect for the rights and well-being of students. The key recommendations are:

- **Developing a clear privacy framework:** Before deploying any IoT/AI system in classrooms, schools and colleges should adopt clear data protection rules and protocols. This includes defining **what data is collected, how it is stored, who has access, and for how long**. Students and parents must be informed about these aspects and, if necessary, give their consent. It is recommended to comply with existing data protection laws (GDPR and domestic legislation) and to consult with IT security experts when designing the system. **Anonymization** of the collected data should be implied wherever possible (e.g. the system may record the total time spoken by an ID instead of the student's name, if the purpose does not require identity). Also, it is important to develop **ethical guidelines** specific to AI in education – to precisely define what

systems can and cannot do with student data (e.g. no collected data should be used for purposes other than improving teaching, or shared with third parties without permission).

- **Transparent communication and involvement of participants:** The implementation will be much more successful if an **educational campaign** among teachers and students is carried out from the beginning. It is necessary **to transparently explain the purpose** of the introduction of IoT/AI technology – what problems it solves, what benefits it brings to everyone, and how exactly it will work. Students should know, for example, that the goal of cameras and microphones is not to "spy" but to record data that may help them (such as tracking their own progress or getting customized support). It is recommended to organize **workshops or presentations** before setting up the equipment, where students could ask questions, express their fears, and get answers. Such open communication will help reduce resistance – when they understand why something is being done and get involved in the process, they are more likely to accept it.

- **Phased and pilot deployment:** Instead of a rapid and comprehensive deployment, a smaller-scale pilot project is recommended. For example, introduce the system first in a few voluntary classes or lectures where both the teacher and the students are agreed and interested in trying it out. The pilot phase makes it possible to test both technical aspects (accuracy, reliability of the system) and user reactions in real conditions. During this period, feedback should be collected from students and professors: what bothers them, what is useful to them, what suggestions they have. On this basis, the system (and the accompanying rules) can be **refined** before wider expansion. This also shows the flexibility of the institution – that it is ready **to learn on the ground** and adapt, instead of imposing a fixed solution.

- **Education on benefits and risks:** In accordance with the recommendations from the research itself, it is crucial **to introduce digital literacy topics into the curriculum and extracurricular activities**, which include the IoT/AI role in society. Students (and teachers) need to be educated about *the benefits and risks* of these technologies. This includes understanding how IoT sensors and AI algorithms work at a basic level – which might demystify some fears. Also, education should cover **the ethics of technology**: why privacy is important, how it can be protected, and what it means to handle data responsibly. The expectation is that an informed student will be less afraid of an unfamiliar system and more appreciative of the good sides, if they see them clearly. One of the ways is to involve students in the implementation itself – for example, students of technical faculties can help in the development of parts of the system as a project task, which builds trust and understanding.

- **Human control and interpretation of results:** Technology should not be seen as a substitute for human interaction, but as a tool that is subject to control. It is recommended that **teachers always have insight and the final say** in interpreting the data that AI collects. In other words, the results of the analysis (e.g., "student X was inactive for 10 minutes") should be understood as **indicators**, not as accusations or final judgments. Teachers are recommended to receive additional training on how to integrate these indicators into their practice – how to check if they are correct (e.g. talk to a student who is said by the system to be distracted, instead of

drawing conclusions immediately) and how to use them positively (give support to those who need it, praise those who have progressed). Also, mechanisms should be provided **to check the accuracy of the** system – e.g. regular evaluations of whether AI correctly recognizes attention or speech, perhaps with the involvement of experts in education and psychology in order to align data interpretations with pedagogical knowledge.

• **Legal framework and institutional policies:** On a broader level, it is recommended that educational institutions work in cooperation with the relevant ministries to **create policies** on the use of AI and IoT in education. This may include the development *of manuals* or *guidelines* that will specify the permitted forms of surveillance, the handling of data, as well as the responsibilities and rights of all parties involved. An example of good practice can be the formation **of an ethics committee** within the institution that will evaluate proposed technology projects (such as the introduction of smart classrooms) and monitor their implementation, protecting the interests of pupils/students. In short, it is necessary to institutionalize the care of ethical aspects – not to leave it to chance or only to technical staff. As the literature suggests, **a lack of clear guidelines** can lead to abuse or mistrust, so proactive regulation is better than responding to problems afterward.

• **Further research and evaluation:** The recommendation for academia is to continue to monitor and explore the **impact of these technologies** as they are introduced. **Longitudinal studies are especially useful** – tracking one generation of students who go through the "smart classroom" for several years, to see how it affects their results, motivation and attitudes. Also, interdisciplinary research (engineers along with educators and psychologists) can provide the best insights into how to design systems that are both effective and ethically acceptable. The results of these surveys should be **transparently shared** with teachers and decision-makers, so that practice is always based on the latest knowledge and evidence, and not on assumptions or technological trends.

The introduction of IoT and AI in classrooms is an achievable goal that can improve education, but only if it is implemented thoughtfully and responsibly. These recommendations underline the need for **a holistic approach**: technological solutions must be accompanied by ethical and pedagogical measures. If these conditions are met, IoT and AI could become valuable allies for teachers and students in creating a more interactive, inclusive, and effective educational environment, while still preserving the dignity and right to privacy of each student. Such a balance is the ultimate goal and meaning of the concept *of a smart classroom* in the humanistic sense.

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