Shodh Sari-An International Multidisciplinary Journal

2025, Vol. 04, Issue 01, 194-201
ISSN: 2959-1376
DOI: https://doi.org/10.59231/SARI7787

IoT Makers: A Collaborative Learning Experience with TinyML

Joy, Helen. K.

Department of Computer Science, Christ Deemed to be University, Bengaluru, India

Abstract

Traditional teaching methods often fail to fully engage students in the field of IoT, particularly when it comes to applying machine learning at the edge. This paper presents an innovative pedagogical approach titled "IoT Makers," aimed at MSc Artificial Intelligence and Machine Learning students. The activity integrates Tiny Machine Learning (TinyML) into IoT projects, encouraging hands-on learning and collaborative problem-solving. The course introduces TinyML as a service (SaaS) using Edge Impulse as the primary platform. Students then develop real-world IoT solutions such as Smart Agriculture, Health Monitoring, and Smart Buildings, utilizing a variety of simulation tools. The results demonstrate enhanced engagement, practical application of theoretical concepts, and improved problem-solving skills among students.

Keywords: Collaborative Learning, IoT, TinyML, Hands-on Learning, Edge Computing, Team Building

Introduction

The rapid advancements in IoT and Artificial Intelligence have highlighted the need for innovative educational practices. The "IoT Makers" project, introduced as part of the IoT module for MSc students in Artificial Intelligence and Machine Learning, provides an interactive, hands-on learning environment. This paper details how TinyML, integrated with IoT, was used to bridge the gap between theoretical knowledge and real-world applications. The study focuses on active learning, teamwork, and problem-solving as key components of the student experience.

Technology has transformed the educational landscape, but traditional lecture-based teaching methods often fall short in providing the practical skills necessary for students to excel in the IoT field [1]. The "IoT Makers" initiative is designed to enhance students' practical understanding of IoT, combined

@2025 International Council for Education Research and Training
ISSN: 2959-1376
2025, Vol. 04, Issue 01, 194-201
DOI: https://doi.org/10.59231/SARI7787

with the growing importance of TinyML. This approach offers students an opportunity to develop and evaluate real-world IoT solutions while encouraging creativity and collaboration.

Literature Review

Traditional Learning vs. Active Learning in IoT Education

While traditional lectures provide a solid foundation in theoretical concepts, they often limit opportunities for critical thinking and creativity, which are essential in fields like IoT and AI [2]. Collaborative learning activities have proven effective in promoting teamwork, communication, and problem-solving, especially when combined with hands-on projects [3].

The Role of TinyML in IoT

TinyML enables machine learning algorithms to run on resource-constrained devices, making it an ideal tool for IoT applications. Integrating TinyML into IoT projects provides students with the ability to implement intelligent, real-time decision-making on low-power devices [4]. Edge Impulse, a leading SaaS platform for TinyML, was used as the primary tool for introducing students to TinyML applications in IoT.

Motivation for "IoT Makers" Pedagogy

The traditional lecture-based approach often results in disengagement, especially when it comes to abstract concepts like TinyML and IoT. To address this issue, "IoT Makers" was developed as an active learning activity that promotes creativity, teamwork, and hands-on experience with IoT systems and TinyML.

Students were introduced to TinyML as a service, with Edge Impulse being the primary tool for implementing TinyML on IoT devices. The activity initially focused on simple input-output tasks, such as detecting device movements. As the course progressed, students applied these skills in more complex scenarios, developing IoT-based solutions in areas like agriculture, healthcare, and smart cities.

Proposed Model

The "IoT Makers" pedagogy was systematically structured through a series of phases designed to gradually build complexity and depth of understanding among students, enhancing their grasp of TinyML and IoT systems.

Phase 1: Introduction to TinyML and IoT

In the initial phase, students were introduced to foundational concepts of Tiny Machine Learning (TinyML) alongside Software as a

@2025 International Council for Education Research and Training
2025, Vol. 04, Issue 01, 194-201
ISSN: 2959-1376
DOI: https://doi.org/10.59231/SARI7787

Service (SaaS) platform, with Edge Impulse identified as the benchmark tool. This phase emphasized hands-on engagement, focusing on sensor data collection methods that equipped students with practical skills for gathering and interpreting data from various IoT devices. Students learned to create simple machine learning models tailored for edge devices, enabling them to understand crucial principles of data processing and model deployment in resource-constrained environments. This introductory phase was crucial in establishing a solid theoretical foundation for subsequent project work.

Phase 2: Project Development and Collaboration

The second phase transitioned students into collaborative teams tasked with developing comprehensive IoT-based systems utilizing TinyML. Teams had the flexibility to choose from several pre-defined real-world scenarios or to devise their own innovative solutions. The scenarios included:

- **Scenario 1: Smart Agriculture Monitoring System** Students designed an IoT system to optimize water usage by monitoring soil moisture and environmental conditions. TinyML models were employed to provide actionable recommendations for optimal irrigation timings, integrating agricultural practices with cutting-edge technology.
- **Scenario 2: Health Monitoring Wearable** Teams developed a wearable device capable of tracking vital signs such as heart rate and body temperature. TinyML algorithms were utilized to analyze real-time data, allowing the device to alert users to potential health risks based on predefined thresholds.
- **Scenario 3: Energy-Efficient Smart Building** In this project, students created a smart building management system that dynamically controlled lighting and HVAC systems based on occupancy and environmental data. The aim was to minimize energy consumption while maintaining occupant comfort.
- **Scenario 4: Smart Waste Management System** Students constructed a waste monitoring system that tracked the fill levels of waste bins and optimized collection routes based on this data. TinyML was leveraged for predictive analytics, leading to improved efficiency in waste management practices.
- **Scenario 5: Environmental Disaster Early Warning System**

@2025 International Council for Education Research and Training
ISSN: 2959-1376
2025, Vol. 04, Issue 01, 194-201
DOI: https://doi.org/10.59231/SARI7787

This project involved the development of a monitoring system that assessed environmental conditions, providing early warnings for potential natural disasters. IoT sensors were deployed to gather critical data, and TinyML was used for real-time data analysis, facilitating timely alerts.

Phase 3: System Design and Implementation: In this phase, each team was responsible for designing their IoT system architecture. Students programmed their IoT devices using selected tools such as Wokwi, Tinkercad, Cooja, or Edge Impulse. The implementation of TinyML models enabled real-time decision-making capabilities, allowing students to observe the immediate effects of their work on system performance. This hands-on experience was pivotal in consolidating their theoretical knowledge through practical application.

Phase 4: Evaluation and Presentation

The final phase required students to present their projects, showcasing system functionality, performance metrics, and the challenges encountered during development. The evaluation criteria for this phase included:

- **Idea Development (25%)**: Assessed the originality, relevance, and feasibility of the proposed idea, ensuring that students' concepts were both innovative and applicable to real-world contexts.
- **System Design and Implementation (25%)**: Evaluated the coherence of the system architecture, the proficiency demonstrated in IoT programming, and the effective use of simulation tools, emphasizing the technical aspects of their work.
- **Write-Up and Documentation (25%)**: Focused on clarity of communication, the connection to established learning outcomes, and thorough explanations of challenges faced during the project, along with the solutions implemented.
- **Simulation/Implementation Output (25%)**: Considered the overall functionality and quality of the final output produced by each team, assessing how well the systems performed against their initial objectives.

Through this structured approach, the "IoT Makers" project effectively combined theoretical knowledge with practical application, fostering an environment conducive to active learning and innovation in IoT and TinyML.

@2025 International Council for Education Research and Training
ISSN: 2959-1376
2025, Vol. 04, Issue 01, 194-201
DOI: https://doi.org/10.59231/SARI7787

Experimental Results and Feedback

The "IoT Makers" project produced compelling results that highlight the effectiveness of hands-on, collaborative learning in the fields of IoT and TinyML. Student feedback indicated high levels of engagement throughout the course, with participants expressing that the practical, project-based nature of the activities significantly enhanced their understanding of theoretical concepts. This engagement was facilitated by the integration of real-world applications, which allowed students to apply their knowledge to tangible problems.

A notable correlation was observed between active participation and successful learning outcomes. Students who engaged more deeply with the project scenarios, such as developing smart agriculture systems and health monitoring wearables, demonstrated a higher level of proficiency in their technical skills. This emphasizes the importance of collaborative problem-solving and active learning in achieving educational objectives. The collaborative nature of the projects not only fostered teamwork but also encouraged the exchange of ideas, which proved beneficial in overcoming technical challenges.

Moreover, student satisfaction with the activity was overwhelmingly positive. The combination of practical implementation, real-time feedback, and the opportunity to work with tools like Edge Impulse enhanced students' technical confidence and enjoyment of the learning process. This indicates that incorporating hands-on experiences into the curriculum can significantly contribute to a positive educational environment.

The scenarios employed in the project were designed to simulate real-world challenges, and the students effectively demonstrated their ability to navigate these complexities. The projects allowed for a comprehensive understanding of IoT system design and the integration of TinyML, preparing students for future careers in an increasingly technology-driven landscape.

In summary, the "IoT Makers" initiative successfully bridged the gap between theoretical knowledge and practical application. The findings underscore the efficacy of an active, hands-on pedagogical approach in enhancing engagement, creativity, and problem-solving skills among students. This model of learning not only prepares students for careers in AI and IoT but also offers a scalable framework that can

@2025 International Council for Education Research and Training
ISSN: 2959-1376
2025, Vol. 04, Issue 01, 194-201
DOI: https://doi.org/10.59231/SARI7787

be applied to various technological disciplines in higher education.

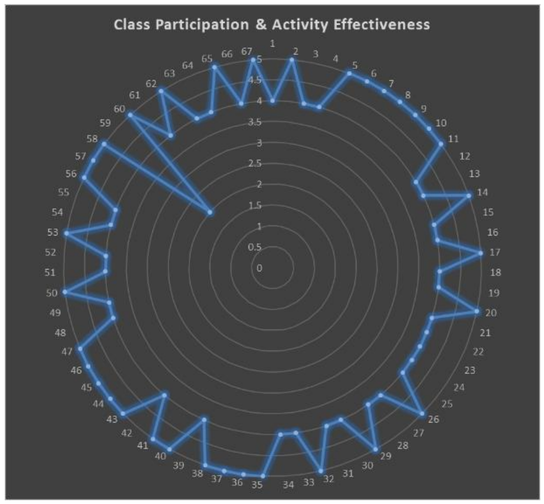

Fig. 1. Activity Effectiveness in Relation to Participation Levels

Fig. 2. Graphical Representation of Activity Relevance and Achieved Learning Outcome

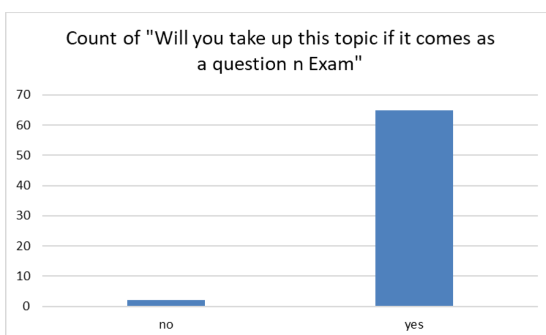

Fig. 3. Measuring Student Happiness After the Activity (Happiness Quotient) Graphical Representation of Activity Relevance and Achieved Learning Outcome

@2025 International Council for Education Research and Training
ISSN: 2959-1376
2025, Vol. 04, Issue 01, 194-201
DOI: https://doi.org/10.59231/SARI7787

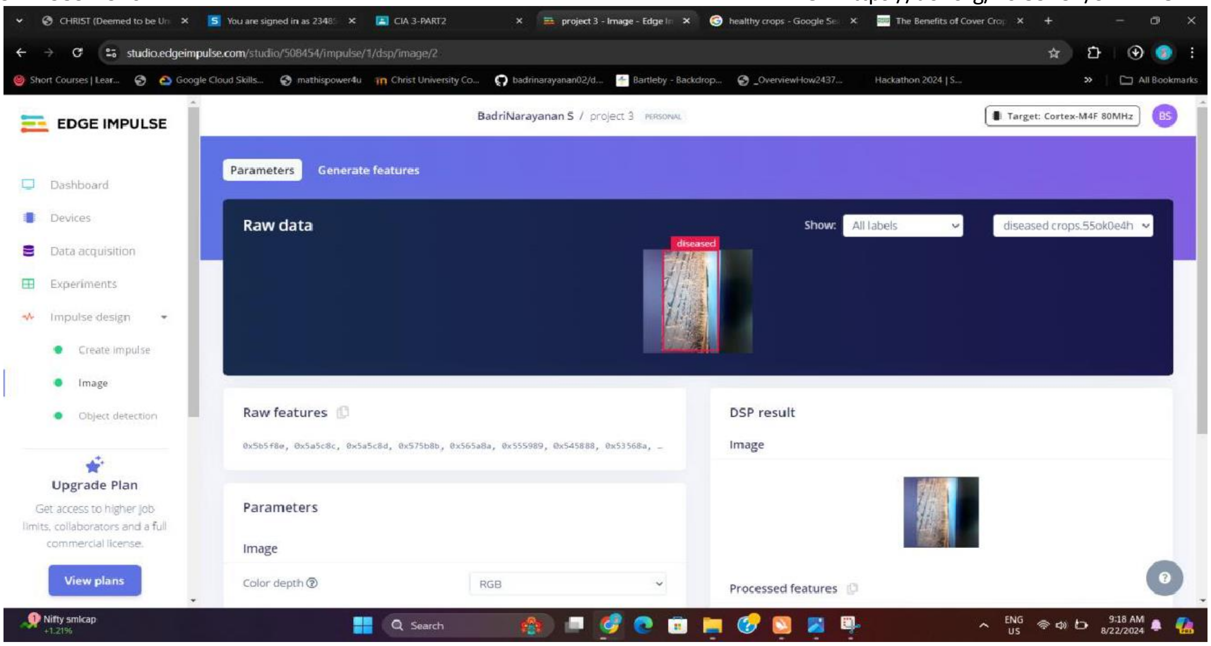

Fig. 4. Sample project outcome for one of the applications for crop detection.

Conclusion

The "IoT Makers" project has proven to be an innovative and effective pedagogical approach for integrating hands-on IoT learning with TinyML applications. By shifting from traditional lecture-based methods to collaborative, project-based learning, students gain practical experience and critical skills essential for the rapidly evolving fields of IoT and AI.

Through real-world scenarios like smart agriculture, health monitoring, and smart buildings, students apply theoretical knowledge to tangible problems, enhancing their technical proficiency and teamwork abilities. The use of tools like Edge Impulse further grounds their understanding of TinyML and edge computing, preparing them for industry challenges. Positive feedback from students highlights the project's success in fostering engagement, creativity, and problem-solving. This approach not only bridges the gap between theory and practice but also equips students with essential skills for the future, making it a valuable model for IoT and AI education.

Acknowledgment

The authors would like to thank the Department of computer science, Christ

@2025 International Council for Education Research and Training
ISSN: 2959-1376
2025, Vol. 04, Issue 01, 194-201
DOI: https://doi.org/10.59231/SARI7787

University, and the MSc Artificial Intelligence and Machine Learning students for their participation and contributions to the "IoT Makers" project.

References

1. Frey, C. B., & Osborne, M. (2017b). *Looking ahead: Our world in 2030. Bertelsmann Stiftung*.
2. Frey, C. B., & Osborne, M. A. (2017a). The future of employment: How susceptible are jobs to computerization? *Technological Forecasting and Social Change*, *114*, 254–280. https://doi.org/10.1016/j.techfore.2016.08.019
3. Kaur, H. (2024). Implications of Educational Philosophy of Sri Aurobindo in 21st Century. *Edumania-An International Multidisciplinary Journal*, *02*(02), 193–203. https://doi.org/10.59231/edumania/9047
4. Johnson, D. W., & Johnson, R. T. (2016). Cooperative learning and critical thinking. *Journal of College Science Teaching*, *45*(4), 95–102.
5. 1.1, Johnson, D. W., Johnson, R. T., & Smith, K. A. (2016). Active learning with cooperative learning. (2004). What the best college teachers do. Bain, K. *Journal of College Science Teaching*. Harvard University Press. 2, *45*(4), 95–102.
6. Özçetin, G., & Karaköse, T. (2016). Collaborative learning in IoT applications. *Journal of Educational Technology & Development*, *8*(2), 119–132.
7. Özçetin Gökçe, F., & Karaköse, T. (2016). The effects of collaborative learning activities on students' creativity in science education. *Journal of Educational Technology & Development Exchange (JETDX)*, *8*(2), 119–132.

Received on Sep 27, 2024
Accepted on Nov 04, 2024
Published on Jan 01, 2025