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Educators Guide

Introducing the 5 Big Ideas in Artificial Intelligence using Internet of Things in STEM education

MARCH 2024 | EMPHASYS CENTRE
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AI4STEM Educators Guide

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Executive Summary

The AI4STEM project introduces students (ages 8-16) to artificial intelligence (AI) through a blend of Internet of Things (IoT) projects, programming, and STEM education, utilizing the Five Big Ideas in AI concept. Educators use hands-on lessons to develop students' understanding of AI and its applications, such as smart agriculture and home automation. The AI4STEM IoT Kit includes essential hardware components for various AI projects, enabling practical learning experiences.

The educational framework supports project-based learning and emphasizes the Five Big Ideas in AI: Perception, Representation & Reasoning, Learning, Natural Interaction, and Societal Impact. It includes a structured approach, age-appropriate learning objectives, and exemplary projects like Microsoft's "Farmbeats for Students." The project also encompasses an online collaboration platform, the AI4STEM Academy, for resource sharing and project showcasing. The curriculum spans modules on AI in everyday life, applications, robotics, vision, speech, and games and puzzles, each offering detailed lessons, ethical considerations, and practical examples to enhance AI education.

The AI4STEM Educator's Guide is an invaluable resource designed to empower educators by offering a step-by step process inside the AI4STEM project and results. The handbook comprises several key sections, including the AI4STEM IoT Kit, the AI4STEM Framework, the AI4STEM Skills & Achievement Framework, the AI4STEM Academy, and AI4STEM Lessons and Experiments. Within the AI4STEM Lessons and Experiments section, topics covered include AI in everyday life, AI applications, AI in robotics, AI in vision, AI in speech, and AI in games and puzzles.

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1. Introduction

The AI4STEM project utilizes the Five Big Ideas in AI concept and a series of IoT projects to develop an educational framework on which students (8-16 years old) will be introduced to artificial intelligence through hands-on lessons, blending the Internet of Things principles, programming and STEM learning outcomes.

By using the project results, educators will be able to arouse their students' interest and increase their awareness of how AI can positively affect their daily lives. Students, with the help of their teachers, will develop a series of IoT projects, such as a smart agriculture system, a weather reporting system, a home automation system, a smart garage door, etc. through which the Five Big Ideas in AI will be explained, namely Perception, Representation & Reasoning, Learning, Natural Interaction, and Societal Impact in order to understand what AI is, how it can simplify processes, what impact AI can have in daily interactions and which implications and challenges society needs to overcome.

2. The AI4STEM IoT KIT

An IoT Kit comprising of an MCU or pocketsize computer, IoT sensors and electronics, that educators and students will use to develop a series of IoT projects.

The inventory list:

Project 1: AI in Everyday Life

- IR sensor module

Project 2: AI in Robotics

- Compact motor driver for BBC micro:bit
- DC gear motor drivers with wire
- Wheels
- Ball caster
- Battery holder (3xAA or 4xAA)
- ESP 8266 Wifi module
- 2xAAA or 2xAA battery holder for ESP module

Project 3: AI Vision

- IO Extender fo Micro:bit
- HuskyLens camera
- Study pack for HuskyLens

Project 4: Ai in Speech

- Sensor:bit

+ some indicative material for the crafting part:

- cardboards

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- Tie wraps
- Glue
- Screws/ nuts

3. The AI4STEM Framework

The AI4STEM educational framework, developed as part of the AI4STEM Erasmus+ project, provides teachers with a structured approach to integrating AI concepts into their lessons using project-based learning and IoT principles. It centers around the Five Big Ideas in AI, breaking down each idea and offering practical ways to introduce them in upper-primary and secondary education. Drawing on the AI4K12 initiative's framework, the document outlines age-appropriate learning objectives and enduring understandings for each idea, accompanied by guidelines for implementation. By adopting a glass-box approach, learners gain insight into how AI systems function. Additionally, the framework explores exemplary projects like Microsoft's "Farmbeats for Students," which merges AI, machine learning, and IoT principles in a garden monitoring system, providing a tangible example for educators to follow. The document suggests steps for implementing each of the Five Big Ideas while supporting project-based learning and IoT practices, ultimately empowering educators to effectively teach AI concepts in their classrooms.

The 5 Big Ideas as reflected by the AI4K12 initiative

Big Idea 1: Perception

The first Big Idea in AI, Perception, involves computers understanding their environment through sensors and sensory signals. Students begin their AI learning journey by grasping this concept, understanding the differences between sensing and perceiving. They learn that perception involves extracting information from sensory signals and can be enhanced through machine learning. Activities like using speech recognition software or creating applications in Scratch help reinforce these concepts across different age groups, fostering a deeper understanding of how computers perceive the world and the potential biases that can affect their perception.

Big Idea 2: Representation & Reasoning

The second Big Idea in AI, Representation & Reasoning, explores how AI "thinks" by constructing representations of the world in the form of data and using reasoning algorithms. It's broken down into concepts like Representation, Search, and Reasoning, with corresponding sub-categories. Students learn about different types of knowledge representation and reasoning methods, understanding how intelligent agents use data structures to understand the world and make decisions. Activities such as using decision trees and graphs help students grasp abstract and symbolic representations, while discussing search algorithms through games like tic-tac-toe aids in understanding reasoning processes. These activities cater to different age groups, facilitating comprehension of the complex concept of Representation & Reasoning in AI.

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Big Idea 3: Learning

The third Big Idea in AI, Learning, emphasizes how computers learn from data to make decisions, primarily through Machine Learning algorithms. This process involves creating representations based on training data, which can be provided by humans or generated by the machine itself. Learning is categorized into three concepts - Nature of Learning, Neural Networks, and Dataset - with corresponding sub-categories and parameters. Key insights include understanding how learning algorithms adjust reasoning models and the importance of large training datasets. Students learn to differentiate between human and computer learning, train classification models using machine learning software, and evaluate trained models' performance. Activities like using Teachable Machine to train models recognizing objects and modifying models to avoid biases engage students in hands-on learning experiences across different age groups, fostering a deeper understanding of Learning in AI.

Big Idea 4: Natural Interaction

The fourth Big Idea in AI focuses on the limitations of intelligent agents in natural interaction with humans. It's divided into four concepts: Natural Language, Commonsense Reasoning, Understanding Emotion, and Philosophy of Mind, with corresponding sub-categories. Key insights include computers' difficulty in understanding figurative language and emotions, as well as the current lack of "Broad AI" or Artificial General Intelligence. Students explore tasks intelligent assistants can perform, analyze chatbot functionality, and discuss the challenges computers face in understanding human behavior and emotions. They learn about the limitations of speech recognition systems and the complexities of human communication. Proposed activities include recording human expressions during conversation, creating chatbots, and researching applications that identify human emotions. These activities engage students in understanding the intricacies of natural interaction and the challenges AI faces in achieving human-like reasoning.

Big Idea 5: Societal Impact

The fifth Big Idea in AI, Societal Impact, explores the positive and negative effects of AI on society and emphasizes the importance of ethical design and deployment of AI-based systems. It's divided into four concepts: Ethical AI, AI and Culture, AI and the Economy, and AI for Social Good, with corresponding sub-categories. Key insights include the consideration of societal values like fairness and transparency in AI design, the impact of AI on various sectors of society, and the need to address biases in AI systems. Students discuss parameters to avoid biases, identify sources of bias in AI, predict societal changes due to AI, and explore how AI can solve societal problems. Activities include discussing fairness in AI applications, analyzing recommender systems' impact on daily life, and designing AI systems to address social issues, engaging students in understanding the ethical implications and societal impact of AI.

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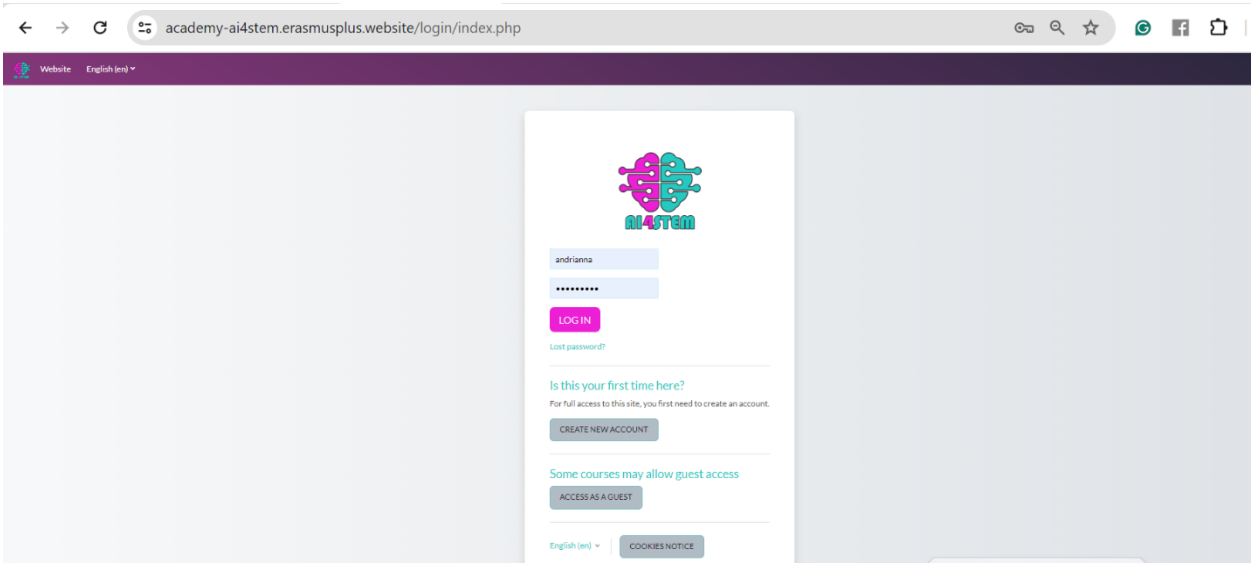
4. The AI4STEM Academy

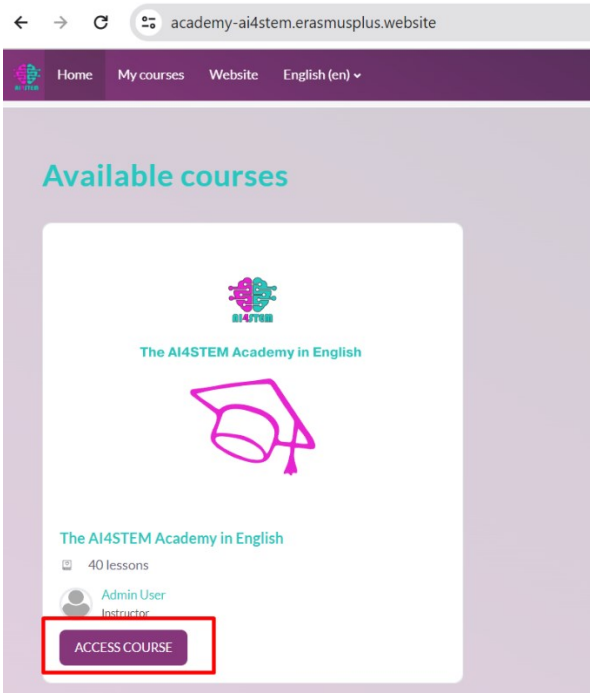
The AI4STEM Academy is an online collaboration space where educators, students, AI enthusiasts and other stakeholders in general will be able to access the project resources, showcase their IoT projects, build synergies, and further develop the project idea and results.

Link to academy: https://academy-ai4stem.erasmusplus.website/



When clicking on log-in and inserting your email and you will receive a confirmation email.

Once you receive it, you will be able to log-in.



Once you locate your course click to Enrol and after you will be able to access the course at any time.

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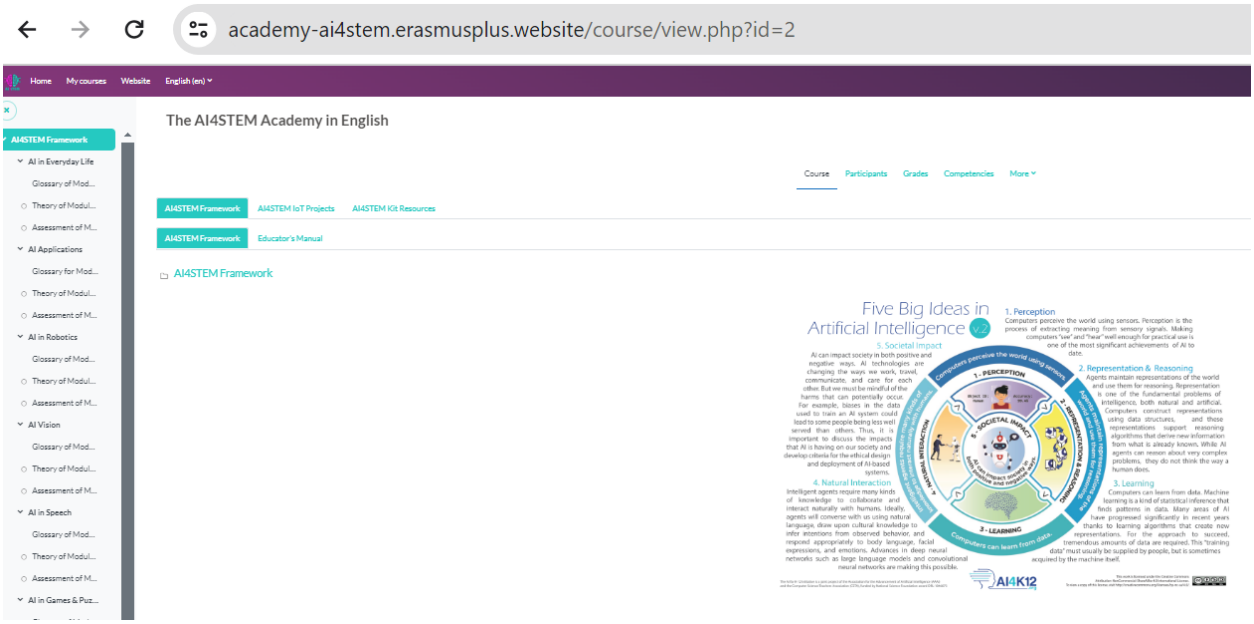
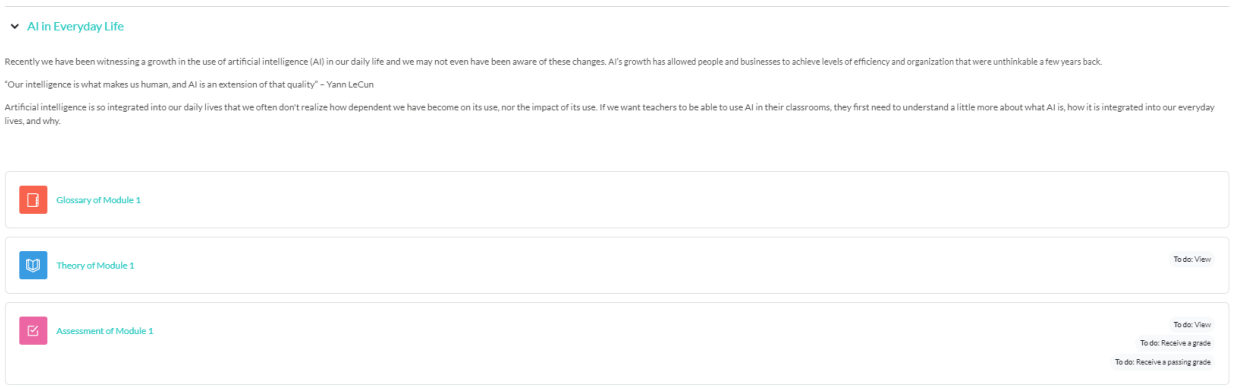
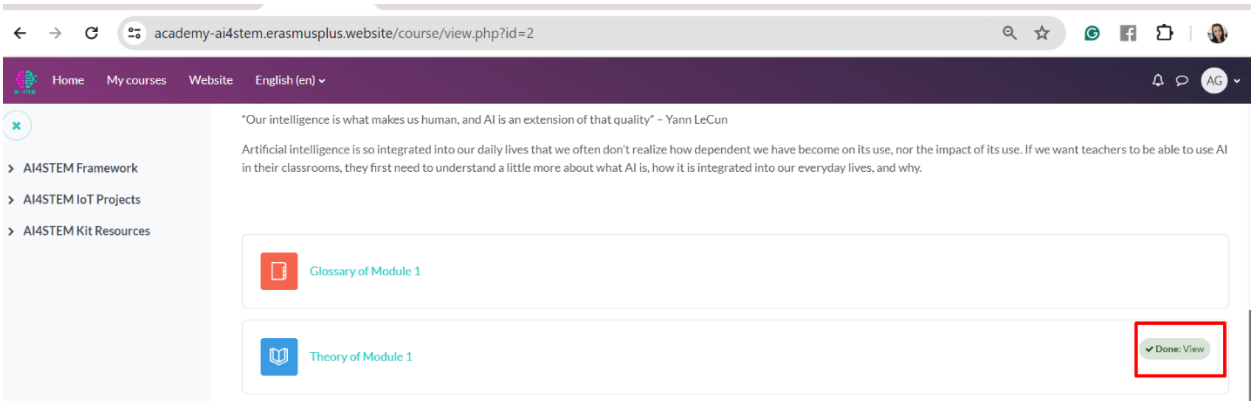


You will be able to navigate the course from the left and view on the right side of your screen. Eache module will appear as you go along.



Each module has this structure: Glossary, Theory and assessment.



Once you are done with the Theory of the Module, you can proceed with the Assessment. You can track your progress with the right button on the right of the course.

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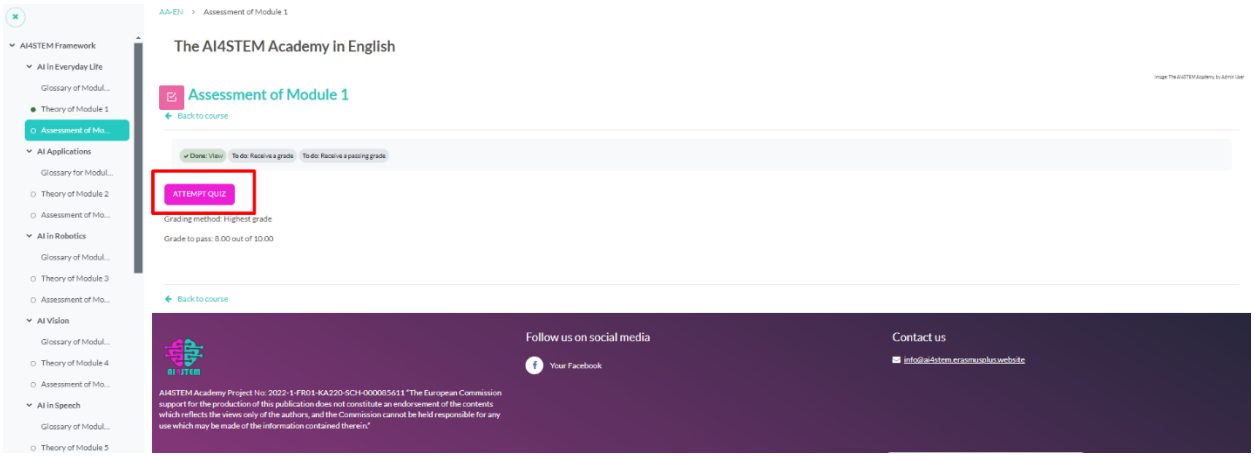
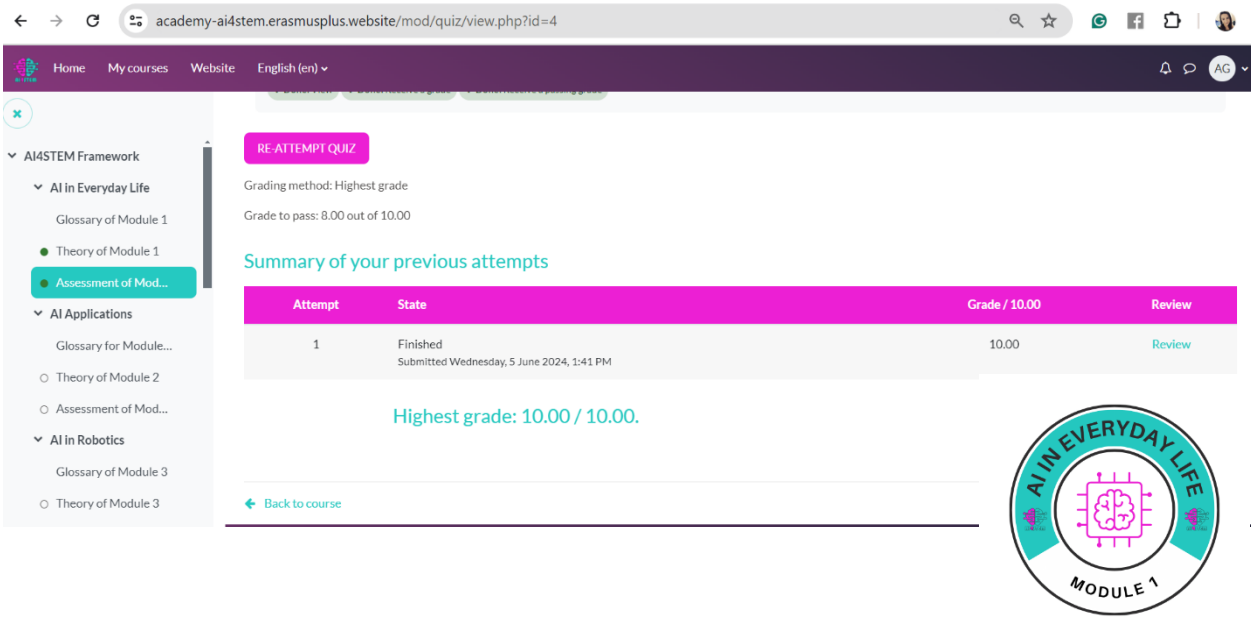


Once you complete the theory you can proceed with the quiz. Click on the Attempt Quiz button and proceed.



Once you complete the quiz you will automatically receive your grade and your Open Badge!

5. AI4STEM Materials and Lessons

M1 – AI in everyday life

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In this module we will explore what is Artificial Intelligence (AI) and how is AI used nowadays in our everyday life. The goal of this module is to help teachers understand and explore this theme in the classroom using AI examples but also exploring the interaction between AI and the Internet of Things (IoT).

Throughout this module, teachers can find simple information about AI, what it is and how is it applied in the everyday life and with the IoT. Teachers will also find examples and some questions/activities suggestions along with the learning objectives of each, to facilitate the explanation of these aspects in the elementary and secondary school classrooms.

It will also be possible to find some scenarios on how AI and the IoT can be approached and introduced through the lens of the 5 Big ideas (as proposed by the AI4K12 initiative), and with a particular focus on the 5th Big Idea, namely Societal Impact.

M2 – AI Applications

Module 2 explores the transformative potential of AI in STEM education through the integration of AI's five big ideas: perception, representation & reasoning, learning, natural interaction, and social impact. It highlights how AI-powered tools, such as learning platforms with AI features, toys, and games, create immersive learning experiences using computer vision, adaptive learning, and personalized interactions. AI-based assessment systems are discussed for their ability to track learning progress, despite their limitations in recognizing unique solutions. Personalized learning environments are shown to aid students with difficulties by offering individualized study plans. Ethical considerations, such as privacy and algorithm bias, are emphasized, advocating for responsible data handling and transparency.

The applications are categorized based on their functionalities and features that facilitate STEM learning:

- Virtual assistants and chatbots
- Advanced AI models developed by OpenAI
- Learning apps and platforms with AI features for STEM subjects (Robotics, Coding, Machine Learning, Mathematics)
- AI-powered NLP platforms (e.g., Grammarly, Quillbot, Quizlet) and computational knowledge engines (e.g., Wolfram Alpha)
- AI-powered toys and games, including puzzles, VR, and computer games

M3 – AI in Robotics

Module 3 integrates AI in robotics within the context of STEM education and IoT. It begins with an overview of robotics, highlighting its applications across various sectors such as industry, medical science, agriculture, and education. Key aspects of AI and IoT in robotics are introduced to familiarize educators with critical concepts.

The module presents several real-life inspired tasks with specific learning objectives to help educators gradually introduce these disciplines in primary and secondary education. These tasks focus on the

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concept of intelligent robots, including their creation, learning processes, and the enhancement provided by internet connectivity.

By connecting the core ideas of AI and IoT to everyday examples, the tasks aim to make learners aware of the main principles and mechanisms of these technologies. The module suggests learning scenarios that blend the five big ideas of AI with IoT and STEM practices through robotics. Implementation examples for each idea are provided, featuring fictional characters who guide their students through project-based learning.

M4 – AI in Vision

Module 4 introduces learners to the process of training and testing an AI model with the HuskyLens camera. They will learn how to set up and configure the HuskyLens camera for image recognition tasks, train the AI model to recognize specific objects or patterns, and finally, interface the camera with a micro:bit to display the AI model's output. Throughout the unit, learners will gain a practical understanding of computer vision, machine learning, and how to integrate AI technologies into real-world projects.

It explores the integration of artificial intelligence (AI) with vision applications, emphasizing its role in enhancing human visual perception and its synergy with the Internet of Things (IoT) for real-time data processing. Covering a range of AI techniques, including image recognition, object detection, facial recognition, and medical imaging, it highlights the importance of AI in these areas. The module begins with an introduction to key concepts and ethical considerations, such as privacy concerns related to IoT-enabled vision systems. It then delves into specific applications like deep learning algorithms for image recognition, the importance of training data, and ethical issues like bias in image data. Real-world applications in object detection, such as surveillance and autonomous vehicles, are discussed alongside ethical considerations. The module also covers facial recognition and emotion detection, highlighting use cases in security, user experience, and healthcare, and addressing ethical concerns about biases and data misuse. In medical imaging, the focus is on automated diagnosis, collaboration between AI and medical professionals, and IoT integration for remote monitoring and real-time diagnostics. Future trends, challenges, and ethical implications of AI and IoT in smart environments are examined, with practical case studies and implementation considerations provided. Finally, the module includes learning scenarios based on the five big ideas of AI, promoting an understanding of perception, reasoning, learning, natural interaction, and societal impact. This comprehensive approach aims to prepare educators and students for the advancements in AI vision applications in STEM education.

M5 – AI in speech

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Module 5 explores the role of AI in speech and voice recognition within STEM education and pedagogical practices. It begins by presenting fundamental aspects of speech recognition techniques to simplify these concepts for educators. A state-of-the-art review of the best speech recognition software is provided, along with discussions on the ethical aspects of AI in speech. Various applications of AI in speech, including tools like ChatGPT, are examined to highlight their advantages and disadvantages in education. The paper also details the five major AI tasks related to speech recognition, providing educators and students with a comprehensive understanding of these tasks. Finally, case studies are presented to illustrate practical implementations and real-world applications.

M6 – AI in Games and Puzzles

Module 6 provides a comprehensive introduction to the integration and utilization of AI in games and puzzles. Learners will explore the core aspects of AI, including perception, representation and reasoning, learning, natural interaction, and societal impact, through real-world examples and case studies. The module examines popular games and puzzles that leverage AI, analyzing their design and underlying AI mechanisms. It also addresses challenges such as creating believable AI characters, ensuring fair gameplay, and maintaining player engagement, alongside ethical considerations like data privacy, AI bias, and the implications of increasingly realistic AI entities. By the end of the module, learners will have a robust understanding of AI applications in games and puzzles, the ability to critically analyze associated challenges and ethical issues, and the skills to appreciate the complex dynamics between AI, games, and society.

Learning Outcomes:

- Understand pivotal concepts and terminology related to AI in games and puzzles, enabling comprehensive discussions and analysis of AI's role in game development.
- Recognize and evaluate the multifaceted applications of AI in games and puzzles, identifying various AI techniques and their impacts.
- Analyze the challenges of AI development and deployment in games, including AI bias, data privacy, and ethical implications.
- Use insights from case studies to identify and propose innovative AI integration opportunities in games and puzzles.
- Predict future trends in AI's role in games and puzzles, considering technological advances and societal shifts.
- Formulate well-grounded perspectives on the societal impact of AI in games and puzzles, understanding its influence on player behavior, game design, and cultural implications.

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**Each Module is accompanied with Lesson plans for teachers and experiments for teachers and students to incorporate hands-on learning of AI Education into STEM. The AI4STEM platform incorporates all materials and documents needed in order to implement into the classroom.*

6. Conclusion

The AI4STEM project successfully integrates AI education into STEM learning for young students through practical IoT projects and a structured framework based on the Five Big Ideas in AI. By engaging students with real-world applications and interactive projects, the initiative fosters a comprehensive understanding of AI, its benefits, and its challenges.

The AI4STEM IoT Kit and the online AI4STEM Academy provide valuable resources for educators, enhancing their ability to teach AI concepts effectively. The project's modules cover diverse aspects of AI, from everyday applications to complex systems in robotics, vision, speech, and gaming, ensuring a well-rounded educational experience. Ultimately, AI4STEM equips students with the knowledge and skills to navigate the evolving landscape of AI and its impact on society, preparing them for future technological advancements and fostering responsible AI usage.

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