M{AI}L

"Teachable Machine Unleashed" Handbook

A Comprehensive Tutorial

Funded by the European Union. However, the views expressed belong to the author(s) alone and do not necessarily reflect the views of the European Union or the Erasmus+ National Agency -INDIRE. Neither the European Union nor the granting administration can be held responsible for them. Project N°: 2024-1-IT02-KA220-SCH-000249373

Funded by the European Union

M{AI}L

Table of Contents

"Teachable Machine Unleashed" Handbook....1
Introduction: The future of learning in your hands....5
Module 1: AI and Machine Learning fundamentals for the classroom....7
1.1 Demystifying Artificial Intelligence (AI)....8
1.1.1 What is AI? Key concepts explained simply....8
1.1.2 A Glimpse into AI history: From curiosity to reality....10
1.2 Understanding Machine Learning (ML): How computers learn....11
1.2.1 What is ML? Basic concepts and everyday examples....11
1.2.2 The ML Learning process: How we "train" a machine....14
1.2.3 Types of Machine Learning: Different approaches to learning....15
1.2.4 The relationship between AI and ML: A partnership for intelligence....16
1.3 The importance of AI and ML literacy for educators....17
1.3.1 Preparing students for the future....17
1.3.2 Evaluating and Selecting AI Tools....19
1.3.3 Integrating AI into the Curriculum....20
1.4 AI as a pedagogical tool: Benefits for teachers and students....21
1.4.1 AI for personalized learning: Tailoring education to individual needs....21
1.4.2 AI for Enhanced Teaching: Empowering Educators with Intelligent Tools....23
1.4.3 AI for Accessibility and Inclusion....24
1.4.4 AI for Assessment and Feedback....25
1.4.5 AI for Educational Content Creation....26
1.4.6 AI for Professional Development....27
1.5 Beyond STEM: AI in other subjects....27
Module 2: Getting started with Teachable Machine: your AI creation lab....30
2.1 Exploring Teachable Machine: AI for everyone....31
2.1.1 Key features and functionality....31
2.1.2 How Teachable Machine simplifies ML....32
2.1.3 Why Use Teachable Machine in education? Key benefits....33
2.2 Preparing your environment: Access and project types....36
2.2.1 Accessing Teachable Machine: Requirements and First Steps....36
2.2.2 Understanding the Project Types: Image, Audio, and Pose....38
2.2.3 Navigating the Teachable Machine Workspace....40
Module 3: Creating Image Projects....46
3.1 Project planning: Defining your image-based AI....47
3.1.1 Identifying classroom applications for image recognition....47

Funded by the European Union

Funded by the European Union. However, the views expressed belong to the author(s) alone and do not necessarily reflect the views of the European Union or the Erasmus+ National Agency -INDIRE. Neither the European Union nor the granting administration can be held responsible for them. Project N°: 2024-1-IT02-KA220-SCH-000249373

3.1.2 Choosing appropriate objects or concepts for classification....48
3.1.3 Defining project success criteria....49
3.2 Data collection and preparation: Building your dataset....51
3.2.1 Gathering image data: Sources and methods....51
3.2.2 Creating image classes: Defining categories for your model....55
3.2.3 Data augmentation: Enhancing your dataset....57
3.2.4 Preparing your data for Teachable Machine....58
3.3 Model training and evaluation: Bringing your AI to life....60
3.3.1 Training your Image model: Step-by-step....60
3.3.2 Evaluating model performance: Understanding accuracy and metrics....65
3.3.3 Troubleshooting and improving your model....66
3.4 Applications in the classroom: Image AI in action....69
3.4.1 Interactive learning activities with image recognition....69
3.4.2 Integrating image AI into subject-specific lessons....70
3.4.3 Assessment strategies using image-based AI projects....72
Module 4: Creating Audio Projects....75
4.1 Project planning: Defining your Audio-based AI....76
4.1.1 Identifying classroom applications for Audio recognition....76
4.1.2 Choosing appropriate sounds or voice patterns for classification....77
4.1.3 Defining project success criteria....79
4.2 Data collection and preparation: Building your dataset for Audio....81
4.2.1 Gathering Audio data: Sources and methods....81
4.2.2 Creating Audio Classes: Defining Categories for Your Model....83
4.2.3 Audio augmentation: Enhancing your dataset....85
4.2.4 Preparing your data for Teachable Machine....86
4.3 Model training and evaluation: Bringing your Audio AI to life....88
4.3.1 Training your Audio model: Step-by-step....88
4.3.2 Evaluating model performance: Understanding accuracy and metrics....92
4.3.3 Troubleshooting and improving your model....93
4.4 Applications in the classroom: Audio AI in action....95
4.4.1 Interactive learning activities with audio recognition....95
4.4.2 Integrating audio AI into subject-specific lessons....97
4.4.3 Assessment strategies using audio-based AI projects....99
Module 5: Creating Pose Projects....102
5.1 Project planning: Defining your Pose-based AI....103
5.1.1 Identifying classroom applications for pose recognition....103
5.1.2 Choosing appropriate poses or movements for classification....104
5.1.3 Defining project success criteria....105
5.2 Data collection and preparation: Building your dataset for poses....107

Funded by the European Union. However, the views expressed belong to the author(s) alone and do not necessarily reflect the views of the European Union or the Erasmus+ National Agency -INDIRE. Neither the European Union nor the granting administration can be held responsible for them. Project N°: 2024-1-IT02-KA220-SCH-000249373

5.2.1 Gathering pose data: Sources and methods..... 107
5.2.2 Creating pose classes: Defining categories for your model..... 110
5.2.3 Augmenting your pose data: More examples, better learning..... 111
5.2.4 Preparing your data for Teachable Machine..... 112
5.3 Model training and evaluation: Bringing your pose AI to life..... 114
5.3.1 Training your pose model: Step-by-step..... 114
5.3.2 Evaluating model performance: Understanding accuracy and metrics..... 118
5.3.3 Troubleshooting and improving your model..... 120
5.4 Applications in the classroom: Pose AI in action..... 121
5.4.1 Interactive learning activities with pose recognition..... 121
5.4.2 Integrating pose AI into subject-specific lessons..... 123
5.4.3 Assessment strategies using pose-based AI projects..... 125
Module 6: Classroom integration strategies: Pedagogical approaches..... 128
6.1 Integrating Teachable Machine into your lesson planning..... 129
6.2 Fostering student-centered learning with AI..... 130
6.3 Ethical considerations and responsible use of AI in the classroom..... 131
6.4 Addressing common challenges..... 133
Module 7: Resources and support: Your guide to continued learning.....136
7.1 Online resources for Teachable Machine.....137
7.2 Further learning in AI and Machine Learning.....138
7.3 Ongoing support and updates.....138
7.4 Practical AI toolkits and educational software for the classroom.....139
7.5 Global ethical frameworks and AI policy guidelines.....140
7.6 Building sustainable practices and project dissemination.....141
Conclusion: Empowering future learners with AI.....143

Funded by the European Union

Funded by the European Union. However, the views expressed belong to the author(s) alone and do not necessarily reflect the views of the European Union or the Erasmus+ National Agency -INDIRE. Neither the European Union nor the granting administration can be held responsible for them. Project N°: 2024-1-IT02-KA220-SCH-000249373

M{AI}L

Introduction: The future of learning in your hands

Welcome to the M{AI}L – Machine and Artificial Intelligence Learning for Education manual. In a rapidly changing world, Artificial Intelligence (AI) is no longer a science fiction concept but a present reality influencing our daily lives. As educators, our role is fundamental in preparing new generations for this future. This manual is a tool designed to help you, as a primary school teacher, introduce AI and Machine Learning (ML) concepts into your classrooms in an accessible, engaging, and relevant way.

What will you find in this manual?

Here, you will delve into the world of AI and ML through Teachable Machine, an intuitive web-based tool from Google that allows you to create machine learning models without needing to write any code. This resource will enable you to:

- **Understand the fundamentals:** We will demystify what AI and ML are with clear explanations and examples relevant to your daily life.
- **Master Teachable Machine:** You will learn step-by-step how to use this tool to create your own image, audio, and pose recognition projects.
- **Apply in the classroom:** We will provide practical ideas and concrete examples to integrate these projects into your science and language classes, aligning them with the curriculum and fostering active learning.
- **Solve challenges:** We will address common difficulties teachers face when integrating technology, offering practical solutions based on the experiences of other educators.
- **Encourage self-paced learning:** You will see how to encourage your students to create their own exercises and explore these concepts at their own pace, fostering their autonomy and interest.

Funded by the European Union

Funded by the European Union. However, the views expressed belong to the author(s) alone and do not necessarily reflect the views of the European Union or the Erasmus+ National Agency -INDIRE. Neither the European Union nor the granting administration can be held responsible for them. Project N°: 2024-1-IT02-KA220-SCH-000249373

Why is it important for you and your students?

Integrating AI into education is essential for several key reasons, many of which have been highlighted by other teachers like you:

- **Future readiness:** AI is transforming the job market, and your students will need skills to adapt to these new environments and potentially pursue careers in AI-related fields. This manual equips you to be a facilitator on that path.
- **Development of key competences:** Learning with AI fosters critical thinking, problem-solving, creativity, and collaboration. These are essential skills for the 21st century.
- **Motivation and engagement:** AI can make learning more interactive and engaging, especially for "digital natives" who are already accustomed to technology. Teachable Machine, being so hands-on, captures students' interest and curiosity.
- **Reduced workload:** By simplifying material and exercise creation, AI can free up your time so you can focus on inspiring and guiding your students.
- **AI literacy:** This manual contributes to your own "AI literacy," giving you the confidence and knowledge to evaluate tools, integrate concepts into your curriculum, and address ethical implications responsibly.

With M{AI}L, you are not just teaching technology; you are cultivating a new generation of critical thinkers and creators who can navigate and contribute to the technology-driven world in an informed and safe manner.

Funded by the European Union

Funded by the European Union. However, the views expressed belong to the author(s) alone and do not necessarily reflect the views of the European Union or the Erasmus+ National Agency -INDIRE. Neither the European Union nor the granting administration can be held responsible for them. Project N°: 2024-1-IT02-KA220-SCH-000249373

M{AI}L

Module 1: AI and Machine Learning fundamentals for the classroom

Funded by the European Union. However, the views expressed belong to the author(s) alone and do not necessarily reflect the views of the European Union or the Erasmus+ National Agency -INDIRE. Neither the European Union nor the granting administration can be held responsible for them. Project N°: 2024-1-IT02-KA220-SCH-000249373

Funded by the European Union

In this module, we will lay the groundwork for understanding Artificial Intelligence (AI) and Machine Learning (ML). You don't need to be a technology expert to grasp these concepts. Our goal is to present them clearly, with simple examples relevant to your daily life and, of course, to the primary classroom.

1.1 Demystifying Artificial Intelligence (AI)

Artificial Intelligence (AI) has emerged as one of the most transformative technologies of our time, rapidly reshaping industries, societies, and even our daily lives. It's no longer a futuristic concept from science fiction; AI is a present reality, and its influence is only set to grow. It is crucial that, as educators, we understand what AI is so we can guide our students to interact with it in an informed and meaningful way.

1.1.1 What is AI? Key concepts explained simply

At its core, Artificial Intelligence is the **capability of a computer system to process information, learn from data, and perform tasks that typically require human intelligence.** These tasks include, but are not limited to, problem-solving, decision-making, understanding language, and recognizing patterns.

Let's think of AI as a collection of tools and techniques that enable computers to do things that previously only humans could, such as:

- **Understanding and responding to natural language:** This means AI systems can process and interpret human language. Think of voice assistants like Siri or Alexa, or automatic translation tools that allow you to communicate in different languages.
- **Recognizing patterns and making predictions:** AI systems can analyze large amounts of data to identify trends, relationships, or anomalies. This allows them to predict future outcomes or make informed decisions. For example, an AI system might predict which movies you'll like based on what you've already watched**.**

Funded by the European Union

Funded by the European Union. However, the views expressed belong to the author(s) alone and do not necessarily reflect the views of the European Union or the Erasmus+ National Agency -INDIRE. Neither the European Union nor the granting administration can be held responsible for them. Project N°: 2024-1-IT02-KA220-SCH-000249373

- **Adapting to new Situations and learning from experience:** Unlike traditional computer programs that follow fixed instructions, AI systems can learn and improve their performance over time. This makes them much more flexible and able to adjust to new situations. For instance, a spam filter in your email learns what emails are junk based on the examples it receives daily.
- **Solving complex problems and making decisions:** AI can tackle difficult problems that are challenging for humans to solve, and it can also automate decision-making processes. Examples include systems that help doctors diagnose diseases or those that manage traffic in a city.

It's important to remember that when we talk about "intelligent behavior" in AI, we don't necessarily mean replicating human consciousness or emotions. AI focuses on machines exhibiting intelligence for specific tasks or problem domains.

AI is fundamentally rooted in computer science, utilizing:

- **Algorithms:** A set of rules or instructions a computer follows to perform a task.
- **Data:** The information the system processes and learns from.
- **Computational power:** The ability of computers to process and manipulate information.

AI is a field of ongoing research and development, and our understanding of it will continue to evolve. This means that, as educators,

Funded by the European Union

Funded by the European Union. However, the views expressed belong to the author(s) alone and do not necessarily reflect the views of the European Union or the Erasmus+ National Agency -INDIRE. Neither the European Union nor the granting administration can be held responsible for them. Project N°: 2024-1-IT02-KA220-SCH-000249373

1.1.2 A Glimpse into AI history: From curiosity to reality

To understand where we are with AI, it's essential to look at where we started. AI's history is a fascinating journey marked by advancements and challenges, periods of great excitement, and others of reduced investment.

- **The dawn of AI (1940s-1950s):** The seeds of AI were sown with the first electronic computers and the question of whether machines could "think". The landmark event was the **Dartmouth Workshop in 1956**, widely considered the official birth of AI as a formal research field. At this stage, researchers tried to teach computers to reason using symbols and logical rules.
- **The era of optimism (1960s):** This was a period of great excitement for natural language processing and computer games. There was a dream of machines that could speak and play like humans.
- **The "AI Winters" (1970s and late 1980s/early 1990s):** Reality clashed with expectations. Limitations of computers and AI approaches at the time (symbolic AI) meant many projects didn't deliver on their promises. This led to reduced funding and interest.
- **The rise of expert systems (1980s):** AI regained momentum with the development of "expert systems," programs designed to mimic human experts' knowledge in specific fields, such as medical diagnosis.
- **The era of Machine Learning (1990s - Present):** This is where AI truly took off. The focus shifted to developing algorithms that allow computers to learn from data without explicit programming. Key factors included increased computational power, the availability of large datasets (thanks to the internet), and advances in algorithms.
- **The Deep Learning revolution (2010s - 2023):** A subfield of ML, "Deep Learning," using Artificial Neural Networks with multiple layers, has achieved astonishing results in image,

Funded by the European Union

Funded by the European Union. However, the views expressed belong to the author(s) alone and do not necessarily reflect the views of the European Union or the Erasmus+ National Agency -INDIRE. Neither the European Union nor the granting administration can be held responsible for them. Project N°: 2024-1-IT02-KA220-SCH-000249373

speech, and language recognition. This powers much of the AI we use today, from virtual assistants to self-driving cars.

- **The Generative Era (2023 - Present):** AI becomes "creative." Large Language Models (LLMs) like ChatGPT and Gemini allow anyone to interact with AI through natural language, while tools like Teachable Machine enable users to build custom ML models easily.

Today, AI is a rapidly growing and pervasive force transforming many aspects of our lives.

1.2 Understanding Machine Learning (ML): How computers learn

Machine Learning (ML), or "Aprendizaje Automático" in Spanish, is a very exciting part of Artificial Intelligence (AI). Think of ML as the way computers learn from experience, much like we do, but from large amounts of data.

1.2.1 What is ML? Basic concepts and everyday examples

ML is about enabling computers to **learn from data, without us having to spell out every single instruction**. It's more like teaching a computer by showing it loads of examples, then the computer figures out the patterns and learns to do the task on its own.

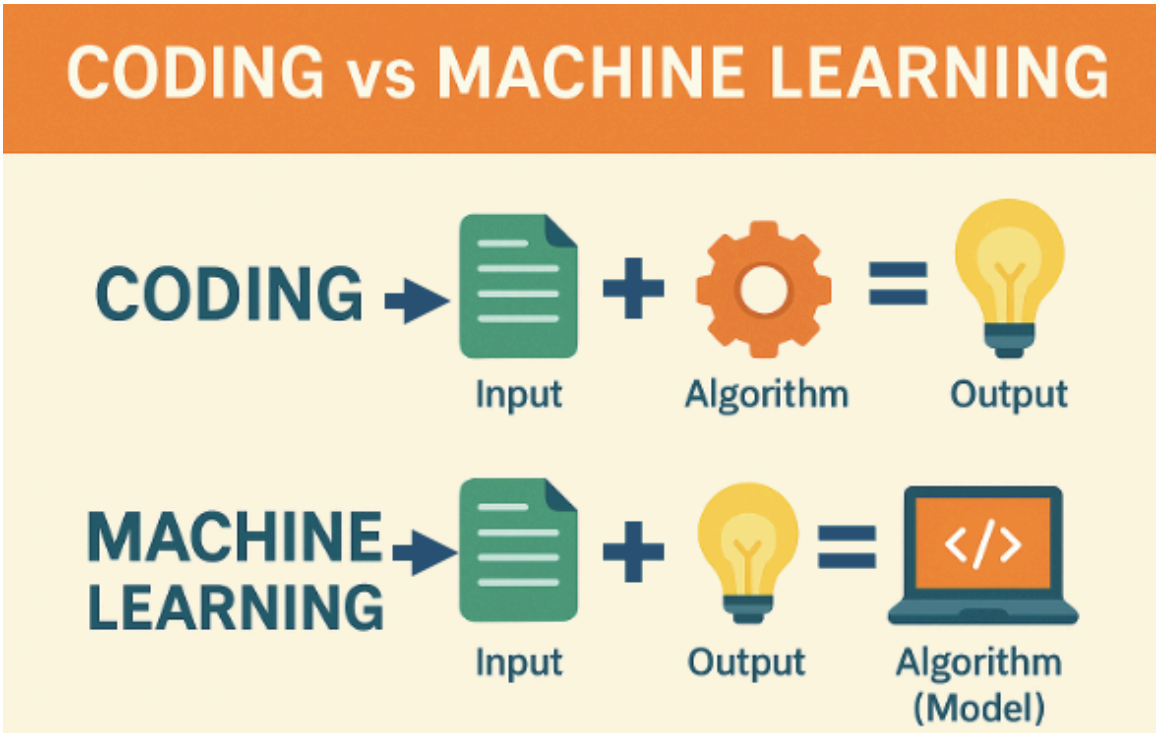
- **The difference from traditional programming:** In classical programming, we tell the computer exactly what to do step-by-step. If something changes, we have to rewrite the instructions. With ML, we provide the computer with vast amounts of examples (data) and let it discover the patterns itself. This allows the ML system to adapt without explicit reprogramming if things change.
- **The power of adaptation:** This ability to learn and adapt is what makes ML so powerful. It allows computers to tackle complex problems that would be very difficult to solve with traditional programming.

Funded by the European Union

Funded by the European Union. However, the views expressed belong to the author(s) alone and do not necessarily reflect the views of the European Union or the Erasmus+ National Agency -INDIRE. Neither the European Union nor the granting administration can be held responsible for them. Project Nº: 2024-1-IT02-KA220-SCH-000249373

- **Relevance to education:** The ML initiative proposes introducing AI and ML concepts at an early stage of teaching and correlating classroom activities with students' technological realities. This not only ensures informed and meaningful interaction with these tools but also helps prevent potential risks related to these tools.

In summary, Machine Learning can be defined as: **"A type of AI that allows computer systems to learn from data, identify patterns, and make predictions or decisions without being explicitly programmed. This learning process means ML models improve as they're exposed to more data."**



Teacher's tip

The chef analogy: Explain to students that AI is like a Chef. Traditional Coding is like following a Recipe (fixed, step-by-step instructions). Machine Learning is the Chef's Palate: after tasting 1,000 soups, the chef learns what "salty" or "sweet" means and creates new recipes without needing a written guide.

Funded by the European Union

Funded by the European Union. However, the views expressed belong to the author(s) alone and do not necessarily reflect the views of the European Union or the Erasmus+ National Agency -INDIRE. Neither the European Union nor the granting administration can be held responsible for them. Project N°: 2024-1-IT02-KA220-SCH-000249373

The core elements of ML are:

- **Learning from data:** ML algorithms learn by examining data, spotting patterns, and extracting useful information. Data is the "fuel" that powers ML.
- **Pattern recognition:** These algorithms are designed to find hidden connections and relationships within data. Imagine a computer spotting trends in student performance or identifying different learning styles.
- **Prediction and decision-making:** ML models use what they've learned to make predictions or decisions when faced with new information. Think of applications like predicting which students might need extra support.
- **Improvement through experience:** ML is a process of ongoing improvement and refinement; models get better as they see more data and practice more.

The importance of data in Machine Learning: The fuel for learning

Data is absolutely crucial in the Machine Learning. ML algorithms learn from data, and the quality and quantity of your data greatly influence how well ML models perform.

- **Data as training material:** ML models are trained on datasets, which are collections of data used to teach the model to recognize patterns and make predictions. Think of these datasets as the "training material" that teaches the ML system what to look for.
- **Data quality is essential:** The accuracy, completeness, and consistency of the data truly matter. If the data is messy or biased, the results will also be messy or biased. This is where data literacy comes in.
- **Data quantity and variety:** ML models often need a lot of data, and data that covers a wide range of examples, to really learn effectively. It's a good idea to encourage students to gather different types of data for their ML projects. The more diverse the data, the better the model will be at handling different situations.

Funded by
the European Union

Funded by the European Union. However, the views expressed belong to the author(s) alone and do not necessarily reflect the views of the European Union or the Erasmus+ National Agency -INDIRE. Neither the European Union nor the granting administration can be held responsible for them. Project N°: 2024-1-IT02-KA220-SCH-000249373

1.2.2 The ML Learning process: How we "train" a machine

In Machine Learning, "learning" isn't about conscious understanding like humans have. It's more about a computer program getting better at something by seeing lots of examples. It's a process of refinement and improvement, very similar to how students learn through practice and feedback.

The simplified ML learning process consists of three main steps:

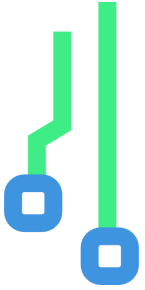
1. **Data collection:** This is where the computer gathers the examples it will learn from.
2. **Model training:** This is the actual "learning" phase, where the computer analyzes the data to find patterns.
3. **Model evaluation:** In this stage, you check how well the computer has learned. You test the system to see how accurate it is.

Key considerations in the learning process:

- **Iteration and refinement:** Developing ML models is often an iterative process. You might need to tweak and improve your model to get the results you want. It's about experimenting and making adjustments to achieve the best outcome. This is very much like teaching, where teachers constantly adjust their methods and approaches.
- **The role of feedback:** ML algorithms use feedback to learn from data. In supervised learning (which we'll use with Teachable Machine), this feedback comes from the labeled data you provide. The computer learns by comparing its predictions to the correct answers. This is similar to how students learn from feedback from their teachers; feedback is essential for growth and improvement.
- **Common pitfalls in Machine Learning and how to avoid them:**
    - **Overfitting:** This means the model learns the training data *too well* and cannot handle new data. It's like a student who only memorizes specific examples but

Funded by the European Union

Funded by the European Union. However, the views expressed belong to the author(s) alone and do not necessarily reflect the views of the European Union or the Erasmus+ National Agency -INDIRE. Neither the European Union nor the granting administration can be held responsible for them. Project N°: 2024-1-IT02-KA220-SCH-000249373



doesn't truly understand the underlying concepts; the model becomes too specialized and cannot generalize to new situations.

- **Underfitting:** Conversely, this means the model doesn't learn the training data well enough. It's like a student who doesn't grasp the basic idea; the model is too simplistic to capture the complexity of the data.
- **Misconception of objectivity:** AI is not always objective or neutral just because it is a machine. AI is a direct reflection of the data it consumes. If the training data is biased or incomplete, the AI will repeat and amplify those biases. It is "opinionated" by the data provided by humans.

- **Continuous learning:** ML models sometimes need to be updated or retrained to continue working well. The world is constantly changing, and ML systems need to adapt. This parallels the concept of lifelong learning: learning is an ongoing process.
- **Iterative and experimental process:** The development of ML models is often an experimental process. It's about exploring different approaches and finding what works best. This encourages a spirit of inquiry, curiosity, and trying new things.

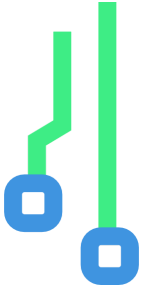
1.2.3 Types of Machine Learning: Different approaches to learning

There are different ways Machine Learning systems can learn. The most relevant for our context are:

- **Supervised learning: Learning with a teacher**
  - **The core idea:** In Supervised Learning, the computer learns from examples where you give it the "answers". It's like a teacher providing a worksheet with an answer key. The computer learns to associate an input with its correct output.
  - **Teachable Machine example:** When you train an image model to recognize "dogs" and "cats," you will provide many photos of dogs *labeled as* "*dog*" and many photos of cats *labeled as* "*cat*". The model learns from these

Funded by the European Union

Funded by the European Union. However, the views expressed belong to the author(s) alone and do not necessarily reflect the views of the European Union or the Erasmus+ National Agency -INDIRE. Neither the European Union nor the granting administration can be held responsible for them. Project N°: 2024-1-IT02-KA220-SCH-000249373



"question-answer" pairs. Teachable Machine primarily relies on this type of learning.

- **Unsupervised learning: Learning by exploring**
  - **The core idea:** Here, the computer learns from examples where you *don't* give it the "answers". Its task is to find patterns and connections on its own, by exploring the information. It's more about discovery.
  - **Example:** Imagine giving the computer a collection of text documents and asking it to find common themes or group similar documents, without telling it the themes beforehand. This isn't as direct for creating projects in Teachable Machine but is an important concept in ML.
- **Reinforcement learning: Learning by doing**
  - **The core idea:** In Reinforcement Learning, the computer learns by interacting with its environment and receiving "rewards" or "penalties" for its actions. It's learning through "trial and error", similar to training a dog: the dog learns by associating actions with rewards or punishments.
  - **Example:** An autonomous car learns to drive by receiving "rewards" for staying in its lane and "penalties" for veering off or crashing. This type of learning is more complex and not directly applicable in Teachable Machine.

1.2.4 The relationship between AI and ML: A partnership for intelligence

It's important to understand that Artificial Intelligence (AI) and Machine Learning (ML) are not the same thing, but they are closely related.

- **ML is a foundational tool for AI:** Think of AI as the overarching goal of creating intelligent machines. ML is one of the primary tools and approaches we use to achieve that goal, enabling AI systems to acquire intelligence through data learning.
- **Synergistic relationship:** AI and ML work hand-in-hand. AI sets the goal (creating intelligent machines), and ML provides the learning capabilities that make those machines

Funded by the European Union

Funded by the European Union. However, the views expressed belong to the author(s) alone and do not necessarily reflect the views of the European Union or the Erasmus+ National Agency -INDIRE. Neither the European Union nor the granting administration can be held responsible for them. Project N°: 2024-1-IT02-KA220-SCH-000249373

intelligent. This partnership is behind many educational tools; many AI tools we use in education rely on Machine Learning.

- **The evolution of AI and the rise of ML:** Over time, ML has become increasingly important within the field of AI. It has emerged as a key driving force behind many of AI's recent advancements.
- **The future of AI and ML:** What happens next in AI will be closely tied to how ML continues to develop. AI literacy (which includes understanding ML) is crucial for educators to be prepared and navigate the future of education.

1.3 The importance of AI and ML literacy for educators

In the 21st century, AI is no longer a niche technology; it has become an integral part of our daily lives and a driving force behind societal change. Therefore, developing **AI literacy** is crucial for everyone, and especially for educators.

AI literacy refers to the ability to understand and use AI technologies effectively, critically evaluate their applications, and consider their ethical and societal implications.

Here's why AI literacy is so important in education, directly addressing the training needs and improvement suggestions you expressed in the report:

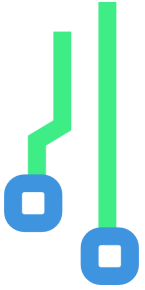
1.3.1 Preparing students for the future

AI is transforming the world of work, and students need to be prepared for this changing landscape. AI literacy equips them with the skills and knowledge to:

- **Adapt to AI-driven workplaces:** Many jobs are being augmented or transformed by AI, and new roles are emerging. Students must be able to work alongside AI systems, understand their capabilities and limitations, and contribute their unique human skills.

Funded by the European Union

Funded by the European Union. However, the views expressed belong to the author(s) alone and do not necessarily reflect the views of the European Union or the Erasmus+ National Agency -INDIRE. Neither the European Union nor the granting administration can be held responsible for them. Project N°: 2024-1-IT02-KA220-SCH-000249373



This includes skills like critical thinking, creativity, complex problem-solving, and collaboration, which are essential for navigating the future of work.

- **Pursue careers in AI-related fields:** The demand for AI specialists is growing rapidly. AI literacy can inspire students to pursue careers in computer science, data science, engineering, and other fields that contribute to the development and application of AI.
- **Become informed citizens in an AI-driven society:** AI is influencing various aspects of society, from healthcare and transportation to communication and entertainment. Students need to understand the implications of AI to participate in informed discussions about its use, regulation, and ethical considerations. This includes understanding the potential benefits and risks of AI, as well as the importance of responsible innovation.

💡**Classroom debate points & real-world scenarios:**

The "standard" student: If we train a model to recognize "good posture" using only photos of students sitting upright in standard chairs, will the AI fail to recognize a brilliant student who uses a standing desk or a wheelchair?

Cultural bias: If we train an AI to recognize "breakfast foods" using only Western images (cereal, toast), what will it classify when it sees a traditional breakfast from Turkey, Greece, or Asia?

To effectively prepare students, educators themselves need to be AI literate. This means:

- **Understanding basic AI concepts:** Educators should have a foundational understanding of what AI is, how it works, and its different applications. This includes familiarity with key terms like machine learning, neural networks, and algorithms.
- **Keeping up-to-date with AI advancements:** The field of AI is constantly evolving, so educators need to stay informed about the latest developments and trends. This can involve reading articles, attending workshops, or participating in online courses.

Funded by the European Union

Funded by the European Union. However, the views expressed belong to the author(s) alone and do not necessarily reflect the views of the European Union or the Erasmus+ National Agency -INDIRE. Neither the European Union nor the granting administration can be held responsible for them. Project N°: 2024-1-IT02-KA220-SCH-000249373

- **Evaluating AI tools and resources:** Educators need to be able to critically assess the quality, effectiveness, and ethical implications of AI tools and resources before integrating them into their teaching practices. This includes considering factors such as bias, privacy, and accessibility.
- **Integrating AI into the curriculum:** Educators should be able to incorporate AI concepts and applications into their curriculum in a meaningful and engaging way. This can involve designing AI-related projects, using AI tools to enhance learning, or discussing the ethical implications of AI in different contexts.

1.3.2 Evaluating and Selecting AI Tools

The rapid growth of AI has led to a proliferation of AI-powered tools and resources for education. Educators need to be able to critically evaluate these tools and select those most appropriate for their students and teaching goals. This process involves considering several factors:

- **Alignment with learning objectives:** The chosen AI tool should directly support the specific learning objectives of the lesson or activity. It needs to be clear how the tool will contribute to students achieving the desired learning outcomes.
- **Pedagogical soundness:** The tool should be based on sound pedagogical principles and promote effective teaching and learning practices. It should not simply be a technological novelty but rather a tool that enhances the learning experience.
- **Ease of use:** The tool must be user-friendly for both teachers and students. Navigating, understanding, and using it effectively should be straightforward. Complex or cumbersome tools can impede the learning process. **This is precisely where Teachable Machine excels due to its highly intuitive nature.**

Funded by the European Union

Funded by the European Union. However, the views expressed belong to the author(s) alone and do not necessarily reflect the views of the European Union or the Erasmus+ National Agency -INDIRE. Neither the European Union nor the granting administration can be held responsible for them. Project N°: 2024-1-IT02-KA220-SCH-000249373

- **Accessibility and inclusivity:** The tool should be accessible to all students, including those with disabilities or diverse learning needs. It should also be inclusive and avoid perpetuating biases or stereotypes.
- **Data privacy and security:** Protecting student data and ensuring their privacy is paramount for the tool. Educators should be fully aware of the data collection and usage policies of any AI tool they intend to use.
- **Ethical implications:** The tool's potential ethical implications, such as bias, fairness, and transparency, must be thoroughly evaluated. Educators should consider how the tool might impact different student groups and if it raises any ethical concerns.
- **Cost-effectiveness:** The tool should offer good value for the investment, proving to be cost-effective. Educators should weigh the tool's cost against its benefits and explore whether more affordable alternatives exist.

1.3.3 Integrating AI into the Curriculum

Integrating AI into the curriculum is essential for providing students with a comprehensive and relevant education in the 21st century. This goes beyond simply using AI tools in the classroom; it involves teaching students about AI itself. Here are some effective strategies for integrating AI into the curriculum:

- **Dedicated lessons on AI:** Incorporate specific lessons or units on AI concepts, applications, and ethical implications. These lessons can cover topics such as: What is AI? How does AI work? Types of AI (e.g., machine learning, natural language processing). Applications of AI in different fields. Ethical considerations in AI.
- **Project-based learning:** Engage students in hands-on projects that involve using or developing AI. Project-based learning provides students with opportunities to apply their knowledge and skills in a meaningful context. Examples of AI-related projects include: Developing a simple AI model using Teachable Machine. Creating an AI-powered chatbot. Designing an AI solution to a real-world problem.

Funded by the European Union

Funded by the European Union. However, the views expressed belong to the author(s) alone and do not necessarily reflect the views of the European Union or the Erasmus+ National Agency -INDIRE. Neither the European Union nor the granting administration can be held responsible for them. Project N°: 2024-1-IT02-KA220-SCH-000249373

- **Cross-curricular connections:** Integrate AI concepts and applications into other subject areas, such as math, science, social studies, and language arts. This helps students see the relevance of AI across different disciplines and promotes interdisciplinary learning. Examples of cross-curricular connections include: Using AI to analyze data in science experiments. Exploring the ethical implications of AI in social studies discussions. Using AI to generate creative writing prompts in language arts.
- **Real-world examples and case studies:** Use real-world examples and case studies to illustrate AI concepts and applications. This helps students see how AI is being used in the real world and its impact on society. Examples include: Discussing the use of AI in healthcare for disease diagnosis. Analyzing the role of AI in social media and its impact on communication. Examining the ethical dilemmas posed by self-driving cars.

1.4 AI as a pedagogical tool: Benefits for teachers and students

Artificial Intelligence is not just a subject to be studied; it is also a powerful tool that can be leveraged by both teachers and students to enhance the learning experience, improve teaching practices, and foster innovation in education. Understanding these benefits is crucial for educators who want to integrate AI effectively into their classrooms.

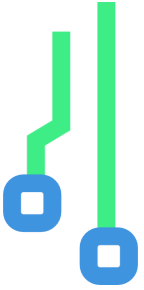
1.4.1 AI for personalized learning: Tailoring education to individual needs

One of AI's most promising applications in education is its capacity to personalize learning experiences for students. Students learn at different rates, have different learning styles, and possess different strengths and weaknesses. AI can help address these individual differences and create more personalized learning pathways.

- **Adaptive learning platforms:** These AI-powered platforms dynamically adjust to the individual needs of each student by:

Funded by the European Union

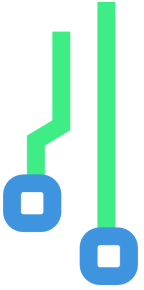
Funded by the European Union. However, the views expressed belong to the author(s) alone and do not necessarily reflect the views of the European Union or the Erasmus+ National Agency -INDIRE. Neither the European Union nor the granting administration can be held responsible for them. Project N°: 2024-1-IT02-KA220-SCH-000249373



  - Assessing their current knowledge and skills.
  - Providing customized learning content and activities.
  - Adjusting the difficulty level based on student performance.
  - Providing targeted feedback and support. These platforms can help students learn at their own pace, focus on areas where they need more help, and receive personalized guidance.
- **Personalized learning paths:** Student data can be analyzed by AI to identify individual learning styles, preferences, and strengths. This information is then used to create personalized learning paths specifically tailored to each student's needs. For example, some students may learn best through visual aids, while others might prefer hands-on activities. AI assists in identifying these preferences and delivering learning materials in the most effective format for each student.
- **Intelligent tutoring systems:** These AI-powered tutoring systems deliver one-on-one instruction and support to students. Their capabilities include:
  - Answer student questions.
  - Provide step-by-step guidance.
  - Offer feedback on student work.
  - Simulate a human tutor, providing personalized attention and support. Intelligent tutoring systems can be particularly beneficial for students who need extra help or are struggling with specific concepts.
- **Personalized feedback and assessment:** Student work can be analyzed by AI to provide personalized feedback on their strengths and weaknesses. This feedback, customized to individual student needs, helps them identify areas for improvement and track their progress over time. AI also automates certain aspects of assessment, such as grading multiple-choice questions or providing initial feedback on written assignments. This capability frees up teachers' time, allowing for a greater focus on individualized student support.

Funded by
the European Union

Funded by the European Union. However, the views expressed belong to the author(s) alone and do not necessarily reflect the views of the European Union or the Erasmus+ National Agency -INDIRE. Neither the European Union nor the granting administration can be held responsible for them. Project N°: 2024-1-IT02-KA220-SCH-000249373



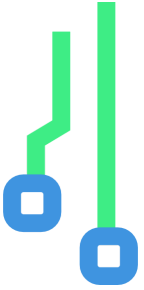
1.4.2 AI for Enhanced Teaching: Empowering Educators with Intelligent Tools

AI also functions as a valuable tool for teachers, providing new avenues to enhance teaching practices, automate tasks, and gain insights into student learning.

- **Automating administrative tasks:** Many administrative tasks typically performed by teachers can be automated by AI. These include:
    - Grading simple assignments.
    - Taking attendance.
    - Scheduling meetings.
    - Communicating with parents. This can free up teachers' time to focus on more important tasks, such as lesson planning, providing individualized support to students, and engaging in professional development.
- **Providing data-driven insights:** Student data can be analyzed by AI to offer teachers insights into student learning. This capability assists teachers in:
    - Identify students who are struggling.
    - Track student progress.
    - Identify areas where the curriculum may need to be adjusted.
    - Make data-informed decisions about their teaching practices.
- **Creating personalized learning resources:** Teachers can be greatly aided by AI in developing personalized learning resources for their students. This might involve:
    - Generating customized worksheets.
    - Creating interactive quizzes.
    - Developing personalized learning paths.
    - Tailoring resources to the specific needs and interests of their students.
- **Supporting students with special needs:** Significant support for students with special needs is available through AI. This technology can:
    - Providing assistive technologies.

Funded by the European Union

Funded by the European Union. However, the views expressed belong to the author(s) alone and do not necessarily reflect the views of the European Union or the Erasmus+ National Agency -INDIRE. Neither the European Union nor the granting administration can be held responsible for them. Project N°: 2024-1-IT02-KA220-SCH-000249373



- Personalizing learning materials.
- Offering individualized support. AI can help create a more inclusive learning environment for all students.

1.4.3 AI for Accessibility and Inclusion

AI holds significant potential to enhance education's accessibility and inclusivity for all learners, including those with disabilities or diverse learning needs.

- **Assistive technologies:** AI powers various assistive technologies that help students with disabilities access and engage with learning materials. Examples include:
  - Screen readers: AI-powered tools convert text to speech, thereby making digital content accessible to students with visual impairments.
  - Speech-to-text software: This AI technology transforms spoken words into text, allowing students with physical disabilities to write and communicate more easily.
  - Translation tools: By translating text and speech into different languages, AI makes learning materials accessible to students who are English language learners.
- **Personalized learning accommodations:** The customization of learning accommodations for students with disabilities or diverse learning needs is facilitated by AI. This may involve:
  - Providing alternative formats for learning materials.
  - Adjusting the pace of instruction.
  - Offering individualized support. AI can help create a learning environment tailored to the specific needs of each student.
- **Early identification of learning difficulties:** Analyzing student data through AI can pinpoint students who may be at risk for learning difficulties. This capability facilitates early intervention and support, effectively assisting students in overcoming challenges and achieving school success.

Funded by the European Union

Funded by the European Union. However, the views expressed belong to the author(s) alone and do not necessarily reflect the views of the European Union or the Erasmus+ National Agency -INDIRE. Neither the European Union nor the granting administration can be held responsible for them. Project N°: 2024-1-IT02-KA220-SCH-000249373

- **Creating inclusive learning environments:** More inclusive learning environments are actively fostered by AI's capacity to:
    - Automating tasks that can be challenging for some students.
    - Providing personalized support.
    - Creating opportunities for all students to participate and engage in learning.

1.4.4 AI for Assessment and Feedback

Assessment and feedback practices in education can be transformed by AI, providing teachers and students with more efficient, personalized, and insightful ways to measure learning and track progress.

- **Automated grading:** Certain types of assessments can be automatically graded using AI. These include:
    - Multiple-choice questions.
    - Short-answer questions.
    - Essays. This can free up teachers' time to focus on providing more personalized feedback to students and engaging in other instructional activities.
- **Personalized feedback:** Student work can be analyzed by AI to provide personalized feedback on their strengths and weaknesses. This feedback, customized to individual student needs, helps them identify areas for improvement and track progress over time.
- **Formative assessment:** The creation of formative assessments that provide students with ongoing feedback on their learning is possible through AI. These assessments serve to:
    - Track student progress.
    - Identify areas where students are struggling.
    - Adjust instruction to meet student needs.

Funded by the European Union

Funded by the European Union. However, the views expressed belong to the author(s) alone and do not necessarily reflect the views of the European Union or the Erasmus+ National Agency -INDIRE. Neither the European Union nor the granting administration can be held responsible for them. Project N°: 2024-1-IT02-KA220-SCH-000249373

- **Adaptive testing:** AI enables the creation of adaptive tests that adjust question difficulty based on student performance. This provides a more accurate measure of student knowledge and skills and can help reduce test anxiety.
- **Analyzing student learning data:** Student learning data is analyzed by AI to provide teachers with insights into student progress and to identify areas where the curriculum may need adjustment. This data-driven approach to assessment contributes to improved instructional effectiveness.

1.4.5 AI for Educational Content Creation

Assistance in the creation of educational content is a significant benefit of AI, making it easier for teachers to develop engaging and effective learning materials.

- **Generating practice questions and quizzes:** AI generates practice questions and quizzes on various topics, offering students opportunities to review and test their knowledge.
- **Creating interactive simulations and virtual environments:** The use of AI makes it possible to create interactive simulations and virtual environments, allowing students to explore and learn in a safe and engaging manner.
- **Developing personalized learning materials:** Teachers receive assistance from AI in developing personalized learning materials tailored to the specific needs and interests of their students.
- **Translating and adapting content:** AI translates educational content into different languages and adapts it to various cultural contexts, thereby increasing its accessibility to a wider range of learners.

Funded by
the European Union

Funded by the European Union. However, the views expressed belong to the author(s) alone and do not necessarily reflect the views of the European Union or the Erasmus+ National Agency -INDIRE. Neither the European Union nor the granting administration can be held responsible for them. Project N°: 2024-1-IT02-KA220-SCH-000249373

1.4.6 AI for Professional Development

AI can also be used to support teacher professional development, providing educators with opportunities to learn new skills, improve their teaching practices, and stay up-to-date with the latest advancements in education.

Supporting teacher professional development is another area where AI proves highly beneficial. It provides educators with opportunities to learn new skills, improve teaching practices, and stay up-to-date with the latest advancements in education.

- **Personalized professional development:** AI analyzes teacher data to provide personalized professional development recommendations. This assists teachers in focusing on areas for improvement and accessing resources most relevant to their needs.
- **Virtual coaching and mentoring:** AI offers virtual coaching and mentoring to teachers, providing feedback on their teaching practices and supporting their professional growth.
- **Access to online resources and communities:** Teachers can connect with online resources and communities through AI, where they can share ideas, collaborate with colleagues, and learn from the field's experts.
- **Data-driven feedback on teaching practices:** AI analyzes classroom data to provide teachers with feedback on their teaching practices. This data-driven approach helps teachers identify areas for improvement and refine their instructional strategies.

1.5 Beyond STEM: AI in other subjects

Artificial Intelligence is not just for computer science or mathematics classes; it is a cross-curricular tool that enriches learning across all disciplines:

Funded by the European Union

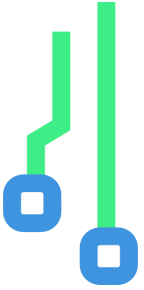
Funded by the European Union. However, the views expressed belong to the author(s) alone and do not necessarily reflect the views of the European Union or the Erasmus+ National Agency -INDIRE. Neither the European Union nor the granting administration can be held responsible for them. Project N°: 2024-1-IT02-KA220-SCH-000249373

- **History & Humanities:** Explain how ML helps researchers read ancient, damaged scrolls by training models to recognize faint ink patterns invisible to the human eye, or how AI analyzes historical archives to categorize artifacts.
- **Music & Art:** Discuss how AI can analyze the "brushstroke style" of painters or the "tempo patterns" of different musical genres to assist in categorizing art history. Students can also explore AI as a creative partner for generative digital art and musical composition.
- **Languages & Literature:** Explore how natural language processing and voice recognition assist in language acquisition, dialect analysis, and automated sentiment analysis (e.g., training a model to detect positive or negative tone in storytelling).
- **Ethics & Social Studies:** Use AI as a lens to analyze digital citizenship, discussing how algorithms influence news feeds, social media recommendations, and global information access.

Funded by
the European Union

Funded by the European Union. However, the views expressed belong to the author(s) alone and do not necessarily reflect the views of the European Union or the Erasmus+ National Agency -INDIRE. Neither the European Union nor the granting administration can be held responsible for them. Project N°: 2024-1-IT02-KA220-SCH-000249373

M{AI}L



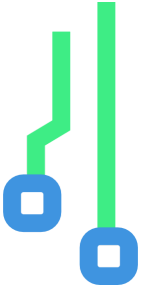
Funded by the European Union. However, the views expressed belong to the author(s) alone and do not necessarily reflect the views of the European Union or the Erasmus+ National Agency -INDIRE. Neither the European Union nor the granting administration can be held responsible for them. Project N°: 2024-1-IT02-KA220-SCH-000249373

M{AI}L

Module 2: Getting started with Teachable Machine: your AI creation lab

Funded by the European Union. However, the views expressed belong to the author(s) alone and do not necessarily reflect the views of the European Union or the Erasmus+ National Agency -INDIRE. Neither the European Union nor the granting administration can be held responsible for them. Project N°: 2024-1-IT02-KA220-SCH-000249373

Funded by
the European Union



Having grasped the fundamentals of Artificial Intelligence and Machine Learning, it is now time to explore a tool designed to bring these concepts to life in your classroom: Teachable Machine. This platform significantly simplifies the process of creating AI models, making it accessible for both you and your students.

2.1 Exploring Teachable Machine: AI for everyone

Teachable Machine is a web-based tool, developed by Google, aimed at making Machine Learning (ML) accessible and understandable to everyone, regardless of their technical background. It represents a significant step towards democratizing AI.

This platform empowers users to create their own ML models directly through a user-friendly interface, entirely without the need to write a single line of code. This capability is a game-changer because, traditionally, building ML models demanded specialized knowledge of programming languages, complex mathematical concepts, and specific ML libraries.

> **Democratizing AI:** Historically, Machine Learning was a domain reserved for experts possessing specialized knowledge and skills in computer science, statistics, and related fields. This limitation restricted its accessibility, preventing many individuals from exploring its vast potential. Teachable Machine aims to break down these barriers, empowering a broader audience—including educators, artists, students, and anyone with a creative idea—to leverage ML's power in innovative and practical ways. It effectively places AI creation tools into the hands of those who might not have had access to them before.

2.1.1 Key features and functionality

Teachable Machine offers a unique and user-friendly approach to engaging with the core concepts of Machine Learning and building practical ML models. Its design prioritizes simplicity and accessibility.

- **Simple interface:** A visual, intuitive, and interactive interface guides users through the entire process of creating and training ML models. This interface is designed to be self-explanatory and easy to navigate, even for individuals with no prior ML experience.
- **Three project types:** Users can create projects focused on three main types of data using Teachable Machine:

Funded by the European Union

Funded by the European Union. However, the views expressed belong to the author(s) alone and do not necessarily reflect the views of the European Union or the Erasmus+ National Agency -INDIRE. Neither the European Union nor the granting administration can be held responsible for them. Project N°: 2024-1-IT02-KA220-SCH-000249373

- **Image projects:** These projects allow for the training of models capable of recognizing and classifying different images.
- **Audio projects:** Models trained here can recognize and classify various sounds.
- **Pose projects:** With these, users can train models to recognize and classify different body poses. This variety provides substantial flexibility, enabling users to explore a wide range of ML applications.

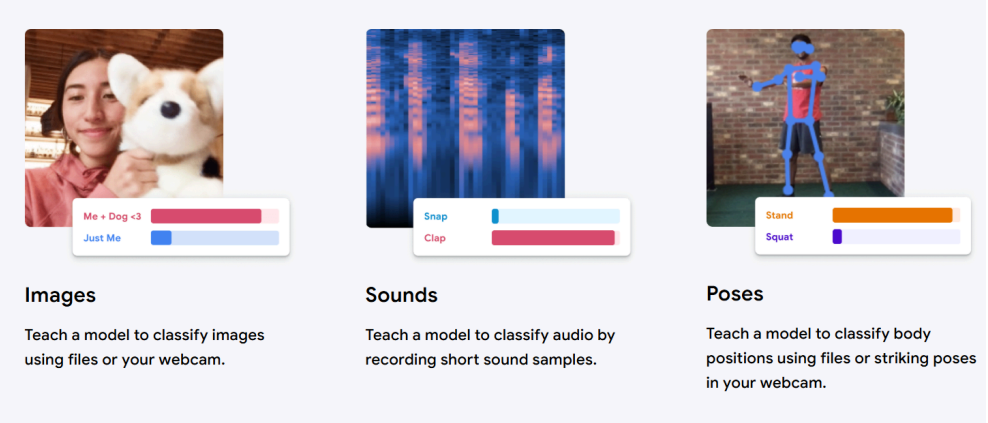


Image 1: Teachable Machine's project types

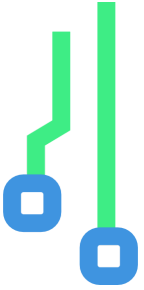
- **Data collection tools:** The platform simplifies the process of gathering necessary data for training ML models. It includes built-in tools that enable users to:
  - Capture images or poses directly using their webcam.
  - Record audio samples using their microphone.
  - Upload existing image, audio, or pose data from their computer or other sources. Such capabilities facilitate the creation of customized datasets tailored to specific project needs.
- **Model training and export:** The platform manages the technical complexities of ML model training in the background, alleviating user concerns about underlying algorithms or code. Once the model is trained, Teachable Machine allows its export in various formats for use in other projects or applications. This feature makes integrating created ML models into websites, apps, and other digital experiences possible.

2.1.2 How Teachable Machine simplifies ML

Teachable Machine significantly lowers the barriers to entry for creating Machine Learning models, making ML more accessible and approachable for a broader audience.

Funded by the European Union

Funded by the European Union. However, the views expressed belong to the author(s) alone and do not necessarily reflect the views of the European Union or the Erasmus+ National Agency -INDIRE. Neither the European Union nor the granting administration can be held responsible for them. Project N°: 2024-1-IT02-KA220-SCH-000249373



- **No code required:** One of the most significant ways Teachable Machine simplifies ML is by eliminating the need for coding. Users can build sophisticated ML models without writing a single line of code, opening ML up to individuals who may not possess programming skills.
- **Visual learning:** The platform emphasizes visual learning, offering visual feedback throughout the model creation process. This aids users in understanding fundamental ML concepts, such as how models are trained, how data is utilized, and how predictions are made.
- **Hands-on experience:** Experimentation, exploration, and creativity are encouraged by Teachable Machine. It provides a hands-on learning environment where users gain knowledge by doing, building projects, and observing real-time results. This active learning approach fosters a deeper understanding of ML and its potential applications.

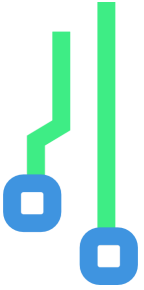
2.1.3 Why Use Teachable Machine in education? Key benefits

Teachable Machine offers a unique and compelling set of benefits for educators looking to introduce Artificial Intelligence (AI) and Machine Learning (ML) concepts into the classroom. It provides a practical, engaging, and accessible way for students of all ages and backgrounds to learn about and interact with these transformative technologies, fostering a deeper understanding and developing essential skills for the future.

- **Accessibility and ease of use:** Teachable Machine's remarkably user-friendly interface and innovative no-code approach make it exceptionally accessible to both students and teachers, regardless of their prior technical expertise or coding proficiency. This ease of use is a critical advantage in education, enabling educators to seamlessly integrate ML into lessons without requiring specialized training, extensive preparation, or significant investments in complex software or hardware. Teachers can focus on the pedagogical aspects of teaching AI and ML, rather than getting bogged down in technical complexities. This accessibility also extends to students, as Teachable Machine provides an intuitive and engaging learning experience that doesn't require prior programming knowledge. Students can dive directly into creating and training ML models, exploring concepts and experimenting with different applications, fostering a sense of empowerment and ownership over their learning.
- **Hands-on learning and engagement:** Active, hands-on learning is strongly promoted by Teachable Machine, offering students the opportunity to create their own Machine Learning projects from start to finish. This experiential learning approach fosters

Funded by the European Union

Funded by the European Union. However, the views expressed belong to the author(s) alone and do not necessarily reflect the views of the European Union or the Erasmus+ National Agency -INDIRE. Neither the European Union nor the granting administration can be held responsible for them. Project N°: 2024-1-IT02-KA220-SCH-000249373



significantly deeper engagement and a more intuitive, lasting understanding of ML concepts compared to traditional methods relying primarily on lectures or textbooks. When students actively participate in building and training their own ML models, they are much more likely to grasp the core principles of how these systems work, how data is used, and how predictions are made. They learn by doing, experimenting, and seeing the direct results of their actions, leading to a more profound and meaningful learning experience. This active participation also fosters curiosity, encouraging students to explore possibilities, ask questions, and delve deeper into the subject matter.

- **Creativity and innovation:** Teachable Machine empowers students to unleash their creativity and apply Machine Learning to solve real-world problems, address community challenges, or create innovative projects expressing their unique ideas. It encourages thinking outside the box, exploring unconventional AI applications, and developing personally meaningful solutions. This emphasis on creativity and innovation is crucial in education, as it fosters entrepreneurship, encourages problem-solving, and prepares students to be adaptable and resourceful in a rapidly changing world. Teachable Machine provides a platform for students to translate ideas into tangible projects, fostering accomplishment and inspiring continued exploration of AI's possibilities.
- **Developing essential skills:** Working with Teachable Machine provides students with a valuable opportunity to develop a wide range of essential skills highly relevant to 21st-century success and beyond. These skills are not only applicable to computer science or technology but are also transferable across various disciplines and career paths. Teachable Machine helps students cultivate:
    - **Problem-solving and critical thinking skills:** By designing and building ML projects, students learn to break down complex problems into smaller, manageable steps, analyze data, identify patterns, and develop logical solutions. They also learn to evaluate their solutions' effectiveness, identify areas for improvement, and refine approaches.
    - **Computational thinking and data literacy skills:** Teachable Machine introduces students to the fundamental principles of computational thinking, such as decomposition, pattern recognition, abstraction, and algorithmic thinking. It also fosters data literacy by helping students understand how data is collected, organized, interpreted, and used to train and evaluate ML models.
    - **Creativity and innovation skills:** This tool encourages students to think creatively, explore new ideas, and develop innovative solutions using ML. It provides a

Funded by the European Union

Funded by the European Union. However, the views expressed belong to the author(s) alone and do not necessarily reflect the views of the European Union or the Erasmus+ National Agency -INDIRE. Neither the European Union nor the granting administration can be held responsible for them. Project N°: 2024-1-IT02-KA220-SCH-000249373

platform for expressing unique perspectives, experimenting with different approaches, and creating original and impactful projects.

- **Collaboration and communication skills:** Teachable Machine projects can effectively foster collaboration among students as they work together to design, build, and test ML models. Students learn to communicate ideas clearly, share findings, provide constructive peer feedback, and work effectively as part of a team. These skills are not only highly relevant to the future of work, where AI and automation play an increasingly significant role, but they are also broadly applicable and valuable across various academic disciplines, career paths, and life situations.

- **Cross-curricular applications:** This AI is a versatile tool, seamlessly integrated into a wide range of subjects and disciplines, extending its educational value beyond traditional STEM (science, technology, engineering, and mathematics) education boundaries. Its adaptability allows educators to connect Machine Learning concepts to different curriculum areas, fostering interdisciplinary learning and enriching the educational experience. Here are some examples of how Teachable Machine can be integrated across different subjects:
  - **Science:** Students can use Teachable Machine to build models classifying different types of plants or animals, identifying weather patterns, or analyzing scientific data. For example, students could create a project identifying different tree species based on leaf images, or one classifying cloud types from weather photographs. This application type enhances students' observation skills, critical thinking, and understanding of the natural world.
  - **Mathematics:** Students can explore data analysis, pattern recognition, and statistical concepts through creating and evaluating ML models.
  - **Arts:** Students can utilize Teachable Machine to create interactive art installations, develop new forms of musical expression, or design projects responding to body movement or sound.
  - **Humanities:** Students can analyze historical images or audio recordings, classify different document types, or explore language use in various contexts.
  - **Social Studies:** Students can investigate social issues, analyze demographic data, or create projects promoting social awareness or addressing community challenges. This cross-curricular applicability makes Teachable Machine a valuable tool for promoting interdisciplinary learning, fostering connections between

Funded by the European Union

Funded by the European Union. However, the views expressed belong to the author(s) alone and do not necessarily reflect the views of the European Union or the Erasmus+ National Agency -INDIRE. Neither the European Union nor the granting administration can be held responsible for them. Project N°: 2024-1-IT02-KA220-SCH-000249373

different subjects, and demonstrating the broad relevance of AI and ML in the world around us.

2.2 Preparing your environment: Access and project types

Teachable Machine is designed to be a readily accessible tool, minimizing technical requirements for users to start creating Machine Learning projects. Its primary mode of access is through a web-based platform, offering several advantages in convenience and ease of use.

2.2.1 Accessing Teachable Machine: Requirements and First Steps

Teachable Machine functions fundamentally as a web application. This means it runs directly within a user's web browser, eliminating the need for any software downloads, installations, or updates. Users can access the platform from any computer or device equipped with a compatible web browser and a working internet connection.

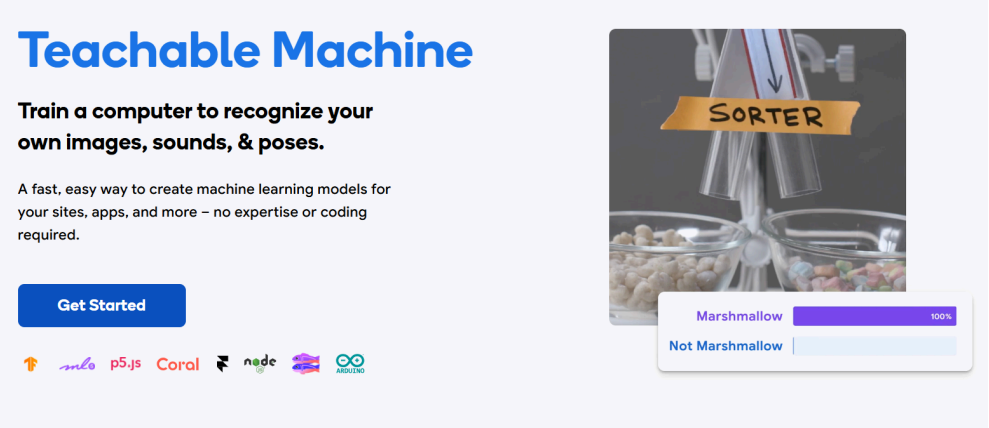


Image 2: Teachable Machine's home page

This web-based approach provides significant flexibility and convenience, as users are not tied to a specific operating system or device. Whether you are using a Windows PC, a macOS computer, a Chromebook, or even a tablet with a web browser, you can access and use Teachable Machine without compatibility issues. Such cross-platform accessibility facilitates easy switching between devices or working on projects from different locations without disruption.

Furthermore, because Teachable Machine runs in the cloud, users avoid concerns about local device storage space. Project data and models are typically saved within the user's Google

Funded by the European Union

Funded by the European Union. However, the views expressed belong to the author(s) alone and do not necessarily reflect the views of the European Union or the Erasmus+ National Agency -INDIRE. Neither the European Union nor the granting administration can be held responsible for them. Project N°: 2024-1-IT02-KA220-SCH-000249373

account (if they choose to sign in), thereby freeing up local resources and ensuring project accessibility from any device.

To use Teachable Machine effectively, users generally need the following:

- **A compatible web browser:** Teachable Machine is designed to work with modern web browsers such as Google Chrome, Mozilla Firefox, Safari, and Microsoft Edge. Utilizing an up-to-date browser version is important to ensure optimal performance and compatibility with all platform features.
- **An internet connection:** As Teachable Machine is a web-based application, a stable internet connection is required to access the platform, load project data, train models, and save progress. The speed of the internet connection can impact loading times and overall platform performance.
- **A Google account (optional but recommended):** While experimenting with Teachable Machine without signing in is possible, creating a Google account enables users to save and access their projects from different devices. This is highly recommended for users planning multi-session projects or wishing to back up their work.
- **Hardware for data input (depending on the project type):**
    - For Image and Pose Projects, a webcam is necessary to capture images or pose data directly within the browser.
    - For Audio Projects, a microphone is needed to record audio samples. Users can also upload data from other sources, such as files stored on their computer or external devices.

💡**Teacher's tip**

Pre-flight technical checklist (Preventing classroom litches):

- **Browser choice:** Best performance is achieved on **Google Chrome** or **Microsoft Edge**. Safari and Firefox may present webcam or microphone permission issues on certain school networks.
- **Hardware conflicts:** Ensure that webcams and microphones are not being actively used by background video conferencing tools (such as Zoom, Teams, or Google Meet) before opening Teachable Machine.
- **School Firewall:** Ask your school IT department to whitelist `teachablemachine.withgoogle.com` to guarantee that models can be trained, previewed, and exported without network blockages.

Funded by the European Union

Funded by the European Union. However, the views expressed belong to the author(s) alone and do not necessarily reflect the views of the European Union or the Erasmus+ National Agency -INDIRE. Neither the European Union nor the granting administration can be held responsible for them. Project N°: 2024-1-IT02-KA220-SCH-000249373

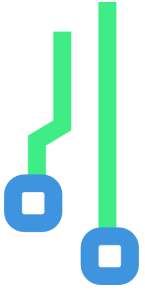
2.2.2 Understanding the Project Types: Image, Audio, and Pose

Teachable Machine offers a versatile platform that caters to different types of data, enabling users to create a variety of Machine Learning models. This versatility is reflected in the three distinct project types available within the platform: Image Projects, Audio Projects, and Pose Projects. Each project type is designed to handle specific data types and facilitates the creation of models tailored to particular applications.

- **Image Projects:** These projects in Teachable Machine empower users to build Machine Learning models capable of analyzing, classifying, and recognizing visual information. The focus here lies in training models to identify and categorize various objects, scenes, or patterns within images.
    - **Functionality:**
        - Users can upload collections of images or capture them directly using their webcam to create datasets for model training.
        - The platform provides tools for defining different "classes" or categories, each representing a specific object, scene, or concept the model will learn to recognize.
        - The trained model can then be used to classify new, unseen images, determining their category.
    - **Applications:** Image Projects are well-suited for a wide range of uses, including:
        - **Object recognition:** Identifying specific objects in images (e.g., tools, animals, plants).
        - **Image classification:** Categorizing images based on content (e.g., landscapes, portraits, indoor/outdoor scenes).
        - **Visual classification in the classroom:** For example, recognizing different types of leaves in a science class, or distinguishing between types of artworks in an art class.
- **Audio Projects:** Users can create Machine Learning models for analyzing, classifying, and recognizing sound information through Audio Projects in Teachable Machine. These projects concentrate on training models to identify and categorize diverse sounds, speech patterns, or musical elements.
    - **Functionality:**
        - Users can record audio samples using their microphone or upload existing audio files to create datasets for model training.

Funded by the European Union

Funded by the European Union. However, the views expressed belong to the author(s) alone and do not necessarily reflect the views of the European Union or the Erasmus+ National Agency -INDIRE. Neither the European Union nor the granting administration can be held responsible for them. Project N°: 2024-1-IT02-KA220-SCH-000249373



        - The platform provides tools to define different "classes" or categories, each representing a specific sound, word, phrase, or audio pattern the model will learn to recognize.
        - The trained model can then classify new, unseen audio samples, determining their category.
    - **Applications:** Audio Projects find suitability in various applications, including:
        - **Sound recognition:** Identifying specific sounds (e.g., animal sounds, environmental noises, musical instruments).
        - **Speech recognition:** Recognizing and classifying spoken words or phrases.
        - **Music classification:** Categorizing audio samples based on genre, artist, or other musical characteristics.
        - **Classroom applications:** Recognizing word pronunciation in a language class, or identifying different musical instruments in a piece.
- **Pose Projects:** Teachable Machine's Pose Projects enable users to create Machine Learning models that analyze, classify, and recognize different body poses and movements. These projects are centered around training models to identify and categorize specific postures, gestures, or movements.
    - **Functionality:**
        - Users can capture pose data directly using their webcam to create datasets for model training.
        - The platform provides tools to define different "classes" or categories, each representing a specific pose, gesture, or movement the model will learn to recognize.
        - The trained model can then classify new, unseen poses or movements, determining their category.
    - **Applications:** Pose Projects prove useful for applications such as:
        - **Gesture recognition:** Identifying specific hand gestures or body movements.
        - **Movement classification:** Categorizing movements in sports, dance, or physical therapy.
        - **Interactive installations:** Creating systems that respond to body movement.
        - **Classroom example:** Identifying if a student is sitting correctly in their chair, or if they are performing a physical education exercise properly. By offering these three distinct project types, Teachable Machine provides a versatile

Funded by the European Union

Funded by the European Union. However, the views expressed belong to the author(s) alone and do not necessarily reflect the views of the European Union or the Erasmus+ National Agency -INDIRE. Neither the European Union nor the granting administration can be held responsible for them. Project N°: 2024-1-IT02-KA220-SCH-000249373

platform for exploring a wide range of Machine Learning applications. The choice of project type depends on the specific goals of the user and the type of data they want to work with.

2.2.3 Navigating the Teachable Machine Workspace

The Teachable Machine workspace is designed to be user-friendly and intuitive, providing a clear and organized environment for creating and managing Machine Learning projects. While the specific layout may evolve slightly with platform updates, the core elements generally remain consistent.

Here's a breakdown of the typical workspace components:

- **Project dashboard:** Upon first accessing Teachable Machine, you are presented with a project dashboard. This area serves as a central hub for managing your existing projects. You find options to:
    - Create a new project: This button or link will initiate the process of starting a new Image, Audio, or Pose Project.
    - View your existing projects: If you have previously created projects, they will be displayed here, allowing you to access and edit them.
    - Access tutorials or resources: Some platforms may provide links to help documentation, tutorials, or example projects to assist you in getting started.

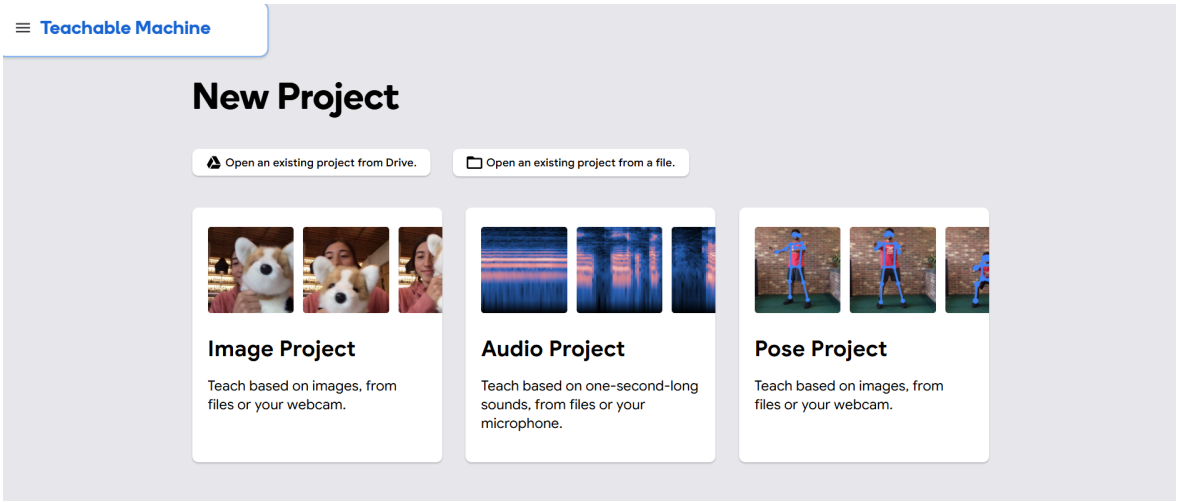


Image 3: Teachable Machine's project dashboard.

Funded by the European Union

Funded by the European Union. However, the views expressed belong to the author(s) alone and do not necessarily reflect the views of the European Union or the Erasmus+ National Agency -INDIRE. Neither the European Union nor the granting administration can be held responsible for them. Project N°: 2024-1-IT02-KA220-SCH-000249373

- **Project view:** Once you have selected or created a project, you will enter the main project view. This is where most of your time is spent working on your ML model. The project view is divided into sections that guide you through the key steps of the ML workflow: data collection, model training, and model preview/export.

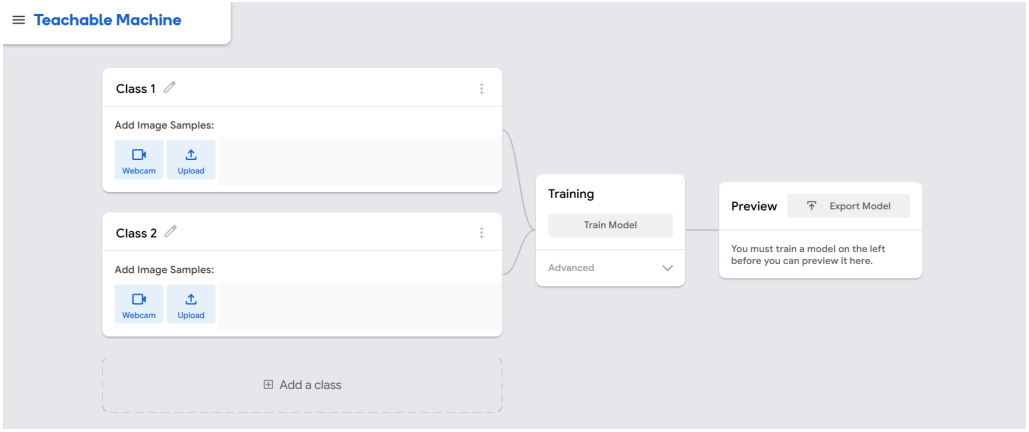


Image 4: Teachable Machine's project view.

- **Data collection area:** This section is dedicated to gathering and managing the data you will use to train your ML model. You will find:
  - Class definition area: This is where you define the different categories or "classes" that your model will learn to recognize. You will usually be able to add new classes, rename them, or delete them as needed.
  - Data input controls: These controls allow you to add data samples to each class. Depending on the project type, you will find options to:
    - Use your webcam to capture images or poses.
    - Use your microphone to record audio samples.
    - Upload data files from your computer.
  - Data display area: This area shows previews or thumbnails of the data samples you have added to each class, allowing you to review and manage your dataset.

Funded by the European Union

Funded by the European Union. However, the views expressed belong to the author(s) alone and do not necessarily reflect the views of the European Union or the Erasmus+ National Agency -INDIRE. Neither the European Union nor the granting administration can be held responsible for them. Project N°: 2024-1-IT02-KA220-SCH-000249373

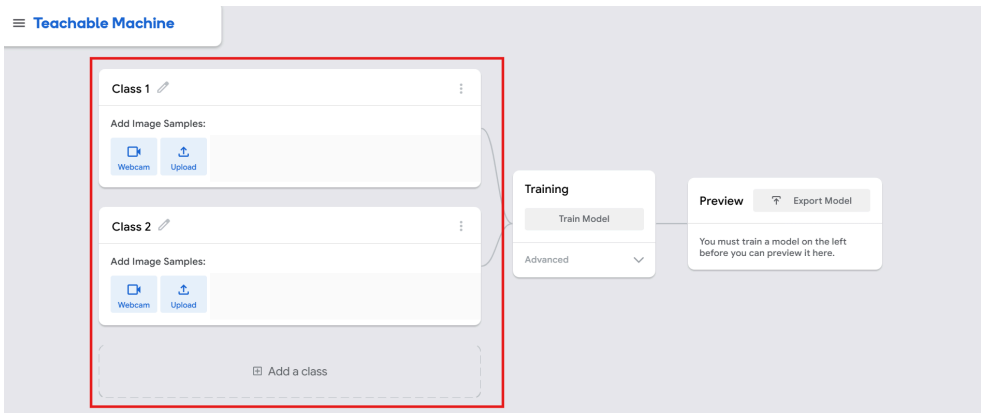


Image 5: Teachable Machine's data collection area.

- **Model training area:** This section focuses on the process of training your ML model. You will find:
    - A "Train Model" button: Clicking this button initiates the training process.
    - Training progress indicators: The platform may provide visual feedback to show the progress of the model training. This includes progress bars, messages, or animations.

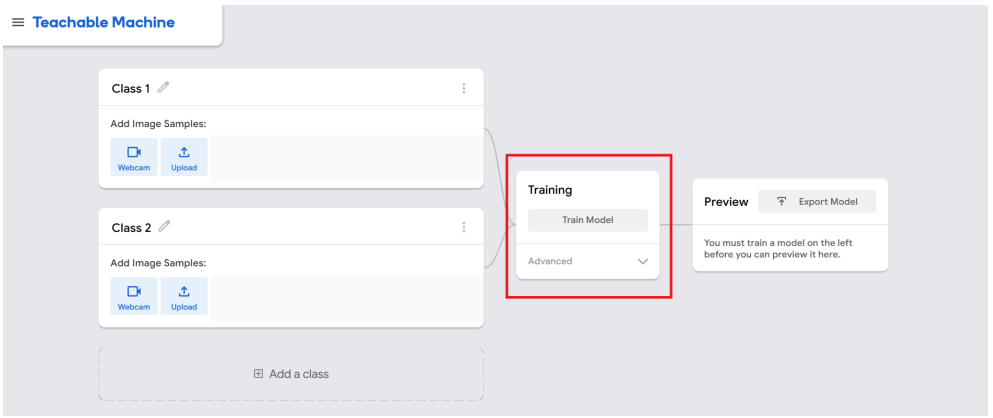


Image 6: Teachable Machine's model training area.

- **Model preview/output area:** This section allows you to test and interact with your trained ML model. You will find:
    - A preview window: This area allows you to provide new input (e.g., through your webcam or microphone) and observe how your model classifies it.
    - Output display: The platform will display the model's predictions, indicating which class it identifies the input as belonging to.

Funded by the European Union

Funded by the European Union. However, the views expressed belong to the author(s) alone and do not necessarily reflect the views of the European Union or the Erasmus+ National Agency -INDIRE. Neither the European Union nor the granting administration can be held responsible for them. Project N°: 2024-1-IT02-KA220-SCH-000249373

- Export options: Once you are satisfied with your model, you will find options to export it in various formats.

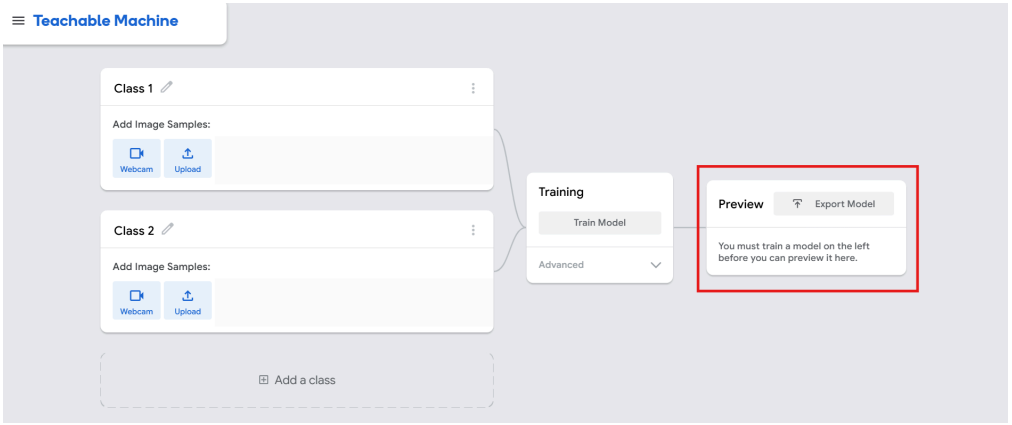


Image 7: Teachable Machine's Model Preview/Output Area.

💡Teacher's tip

Which export option is right for your class?

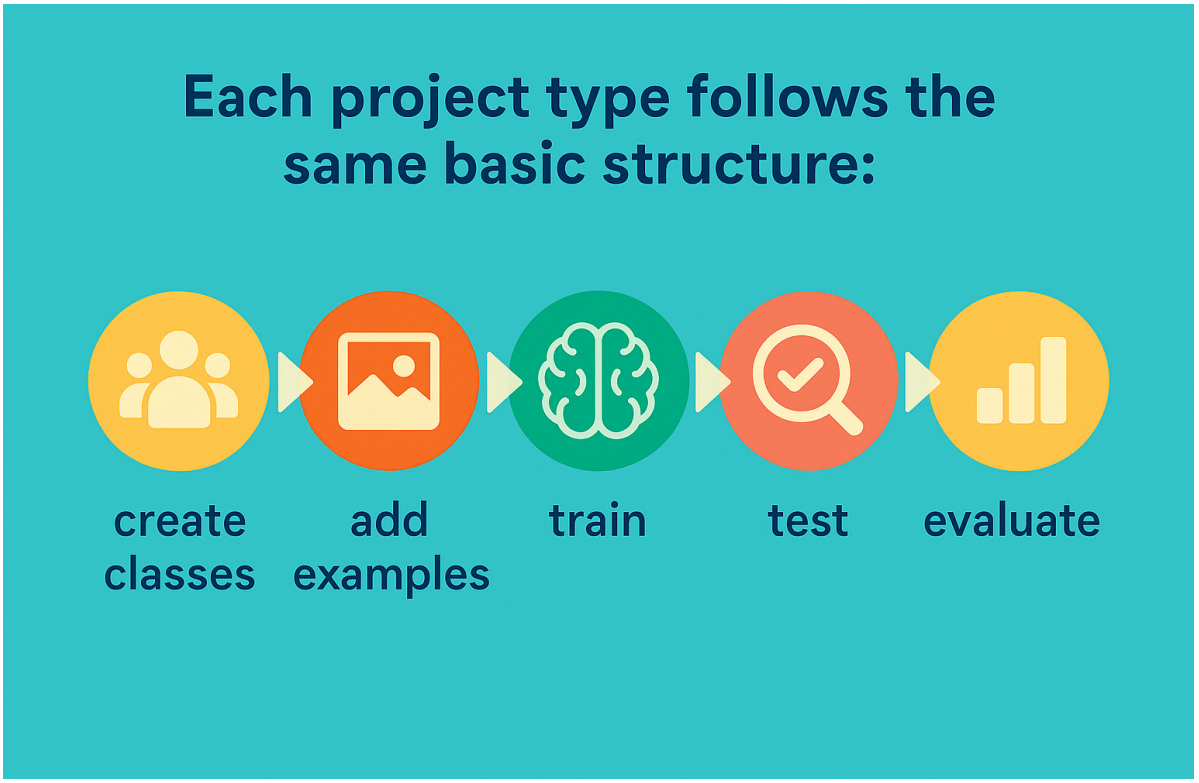
- **The shareable link (Easiest & recommended for most classes):** Ideal for primary and secondary students to send their completed work to the teacher or peers. Just upload the model to Google's free cloud servers and copy the generated URL. No coding is required!
- **Download model:** Choose this option if you want to store the model files locally or use them inside block-based environments like mBlock or Scratch (via extensions).
- **Code snippets (JavaScript / p5.js):** Best for advanced Computer Science or IT classes where students are building custom web applications and want to embed their AI model into real web code.

- **Navigation and Controls:** Throughout the Teachable Machine workspace, various navigation elements and controls will assist you in moving between sections and performing actions. These might include:
  - Buttons and links: For navigating between different areas of the platform or initiating actions.
  - Menus: For accessing settings, options, or help resources.
  - Labels and instructions: To guide you through the process and provide helpful information. While Teachable Machine's workspace is designed to be intuitive,

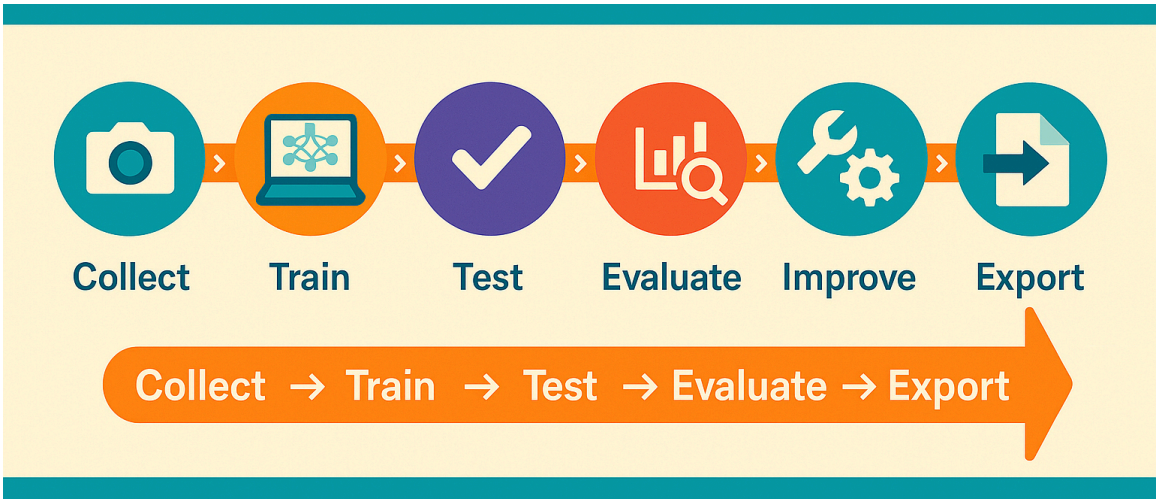
Funded by the European Union

Funded by the European Union. However, the views expressed belong to the author(s) alone and do not necessarily reflect the views of the European Union or the Erasmus+ National Agency -INDIRE. Neither the European Union nor the granting administration can be held responsible for them. Project N°: 2024-1-IT02-KA220-SCH-000249373

exploring the interface and familiarizing yourself with its different sections and controls before starting a project is always a good idea.



Teachable Machine uses an easy-to-follow workflow that teachers can model during lessons. This cycle helps students visualize how AI systems learn and improve.



Funded by the European Union

Funded by the European Union. However, the views expressed belong to the author(s) alone and do not necessarily reflect the views of the European Union or the Erasmus+ National Agency -INDIRE. Neither the European Union nor the granting administration can be held responsible for them. Project N°: 2024-1-IT02-KA220-SCH-000249373

Each phase can become a mini-lesson: data collection teaches ethics and accuracy; training develops patience and observation; evaluation encourages reflection and teamwork.

Funded by the European Union. However, the views expressed belong to the author(s) alone and do not necessarily reflect the views of the European Union or the Erasmus+ National Agency -INDIRE. Neither the European Union nor the granting administration can be held responsible for them. Project N°: 2024-1-IT02-KA220-SCH-000249373

M{AI}L

Module 3: Creating Image Projects

Funded by the European Union. However, the views expressed belong to the author(s) alone and do not necessarily reflect the views of the European Union or the Erasmus+ National Agency -INDIRE. Neither the European Union nor the granting administration can be held responsible for them. Project N°: 2024-1-IT02-KA220-SCH-000249373

Funded by
the European Union

Before embarking on the creation of your first Image Project in Teachable Machine, laying a solid foundation through careful planning and preparation is essential. This module guides you through the initial steps of defining your project, identifying suitable applications, and setting clear success criteria.

3.1 Project planning: Defining your image-based AI

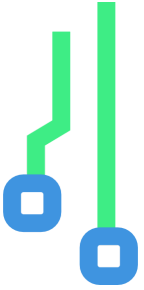
3.1.1 Identifying classroom applications for image recognition

Image recognition, powered by Machine Learning, offers a wealth of exciting possibilities for transforming teaching and learning in the classroom. This technology can create interactive learning experiences, automate tasks, and provide students with new ways to explore and understand the world around them. Here are some examples of classroom applications for image recognition:

- **Object identification and classification:** Image recognition proves useful for creating tools that help students identify and classify objects in images. This application is particularly valuable in subjects like science, where students can build models to recognize different types of plants, animals, rocks, or cells. For example, students could develop a project identifying different tree species based on images of their leaves, or classify various cloud types from weather photographs. This activity enhances students' observation skills, critical thinking, and understanding of the natural world.
- **Image-based quizzes and games:** Integrating image recognition into interactive quizzes and games makes learning more engaging and enjoyable. Teachers, for instance, can create a quiz where students identify historical figures from portraits, or a game where they match images of famous landmarks to their names. This type of application offers immediate feedback to students, making learning interactive and fun.
- **Assistive technologies:** Image recognition can be utilized to develop assistive technologies for students with disabilities. A project, for example, might help visually impaired students identify objects in their environment, or assist students with learning disabilities in recognizing and classifying different symbols or icons. This application promotes inclusivity and provides personalized student support.
- **Art and design projects:** Explore creative applications in art and design using image recognition. Students could create a project recognizing different art styles or artists, or one generating artwork based on recognized images. This fosters creativity, innovation, and an appreciation for art and design.

Funded by the European Union

Funded by the European Union. However, the views expressed belong to the author(s) alone and do not necessarily reflect the views of the European Union or the Erasmus+ National Agency -INDIRE. Neither the European Union nor the granting administration can be held responsible for them. Project N°: 2024-1-IT02-KA220-SCH-000249373



- **Enhancing science experiments:** Image recognition can automate data collection and analysis in science experiments. Students, for example, could create a project that automatically counts objects in an image, or measures plant growth over time based on image analysis. This application saves time and improves the accuracy of scientific investigations.
- **Supporting language learning:** Tools to aid students in learning new languages can be developed using image recognition. For instance, students might create a project recognizing objects and displaying their names in different languages, or one assisting in reading by recognizing letters and words in images. This makes language learning more visual and interactive.

These examples represent just a few of the many classroom applications for image recognition. The possibilities are vast, limited only by the creativity and ingenuity of educators and students.

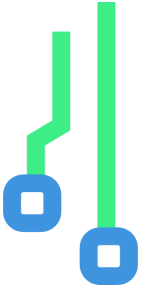
3.1.2 Choosing appropriate objects or concepts for classification

Selecting the right objects or concepts for your Image Project is crucial for ensuring its success and educational value. Your choices directly influence the project's complexity, the feasibility of data collection, and its relevance to your learning objectives. Here are some key considerations for choosing appropriate objects or concepts for classification in Teachable Machine:

- **Simplicity and distinguishability:** Start with objects or concepts that are visually distinct and easy to differentiate. Avoid categories that are too similar or possess subtle differences, as these might prove difficult for the model to learn. For instance, instead of attempting to classify various cloud types (which can be challenging due to their varying shapes and appearances), begin with something simpler, such as classifying images of fruits (e.g., apples, bananas, oranges), where visual differences are more pronounced. As students gain experience, they can gradually advance to more complex classification tasks.
- **Relevance to learning objectives:** Choose objects or concepts that align directly with your specific learning objectives and curriculum goals. Select categories that will help students acquire new information, develop specific skills, or explore relevant topics. For example, in a science lesson about plants, students could create a project classifying different types of leaves or flowers. If teaching a history lesson, students might create a project identifying various historical artifacts or landmarks. Ensure the project supports and enhances the overall learning experience.

Funded by the European Union

Funded by the European Union. However, the views expressed belong to the author(s) alone and do not necessarily reflect the views of the European Union or the Erasmus+ National Agency -INDIRE. Neither the European Union nor the granting administration can be held responsible for them. Project N°: 2024-1-IT02-KA220-SCH-000249373



- **Feasibility of data collection:** Consider the ease and practicality of collecting sufficient data for your chosen objects or concepts. Select categories for which a diverse and representative dataset can be readily obtained. If planning to capture images using a webcam, choose objects easily accessible and photographable within your classroom or learning environment. If using existing images, ensure access to a suitable collection online or from other resources. Avoid categories that are difficult to capture or require specialized equipment or environments.
- **Clarity of categories:** Define clear and unambiguous categories for your project. Ensure minimal overlap or ambiguity exists between these categories. Each category must represent a distinct and well-defined object or concept. Avoid categories that are too broad or easily confused with one another. For example, instead of broad categories like "animals" and "pets," opt for distinct categories like "cats," "dogs," and "birds".
- **Student engagement and interest:** Choose objects or concepts likely to engage and interest your students. Select categories relevant to their lives, hobbies, or interests. Student interest in a project often translates to higher motivation for participation and learning. Consider involving students in the selection process by brainstorming ideas together and allowing them to choose appealing categories.
- **Ethical considerations:** Always be mindful of any ethical considerations related to your chosen objects or concepts. Avoid categories that could be offensive, discriminatory, or harmful. If working with images of people, ensure appropriate consent is obtained and privacy is protected. Choose categories that promote positive values and responsible use of technology.

By carefully considering these factors, you select appropriate objects or concepts for your Teachable Machine Image Projects, ensuring they are educationally valuable, engaging, and ethically sound.

3.1.3 Defining project success criteria

Establishing clear success criteria before you begin your Teachable Machine Image Project is crucial for evaluating its effectiveness and determining whether it has achieved its intended purpose. Success criteria provide a benchmark against which you can measure your project's performance and identify areas for improvement. They also help maintain focus during the development process and ensure you remain on track to achieve your goals. Here's a guide to defining effective project success criteria:

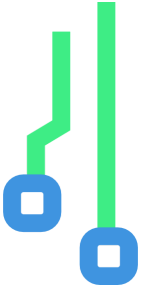
Funded by the European Union

Funded by the European Union. However, the views expressed belong to the author(s) alone and do not necessarily reflect the views of the European Union or the Erasmus+ National Agency -INDIRE. Neither the European Union nor the granting administration can be held responsible for them. Project N°: 2024-1-IT02-KA220-SCH-000249373

- **Accuracy and performance metrics:** Setting targets for your image recognition model's accuracy and performance is a common way to define success.
    - **Overall accuracy:** Determine the minimum acceptable percentage of correct classifications. For instance, a goal might be to achieve 90% overall accuracy, meaning the model correctly classifies 90% of the images presented to it.
    - **Class-specific accuracy:** For more important or challenging classes, specific accuracy targets can be set for each. For example, a higher accuracy might be required for identifying critical objects in a medical diagnosis project.
    - **Precision and recall (Simplified):** These metrics offer a more detailed understanding of your model's performance. "Precision" indicates how often the model was correct when it said something belonged to a certain class. "Recall" measures how often the model correctly identified something that *actually* belonged to a certain class. A balanced model typically performs well on both.
    - **Response time:** If real-time image recognition is required, set a target for the maximum acceptable response time. This measures the time taken for the model to process an image and provide a classification.
- **Functionality and usability:** Define criteria related to your project's functionality and usability, especially if it's intended for a specific application or user group.
    - **Ease of use:** If your project includes a user interface, criteria for its ease of use and intuitiveness must be defined. Consider if users can easily interact with the model and understand its output.
    - **Integration:** For projects intended for integration with another system or application, define criteria for successful integration. Verify if it seamlessly connects and exchanges data with the other system.
    - **Accessibility:** If your project targets a diverse user group, establish criteria for its accessibility. Is it usable by individuals with disabilities?
- **Educational impact (If applicable):** For projects designed for educational purposes, define criteria related to their impact on student learning.
    - **Learning outcomes:** Does the project assist students in achieving the intended learning outcomes? Can students demonstrate improved knowledge or skills after using the project?
    - **Engagement:** Does the project engage students and motivate them to learn? Do students find the project interesting and enjoyable?
    - **Student feedback:** Collect feedback from students regarding their experience with the project. Do they find it helpful, informative, or enjoyable?

Funded by the European Union

Funded by the European Union. However, the views expressed belong to the author(s) alone and do not necessarily reflect the views of the European Union or the Erasmus+ National Agency -INDIRE. Neither the European Union nor the granting administration can be held responsible for them. Project N°: 2024-1-IT02-KA220-SCH-000249373



- **Technical requirements:** Define criteria related to any specific technical requirements for your project.
    - **Platform compatibility:** Does the project operate correctly on the intended platforms or devices?
    - **Resource usage:** Does the project utilize resources efficiently? Does it run smoothly without consuming excessive processing power or memory?
- **Ethical considerations:** Incorporate ethical considerations into your success criteria.
    - **Bias mitigation:** Does the project demonstrate fairness and minimize bias in its predictions?
    - **Privacy protection:** Does the project protect user privacy and handle data responsibly?

Examples of success criteria:

- "The image recognition model achieves an overall accuracy of 92% in classifying images of different types of leaves."
- "Students using the image-based quiz demonstrate a 20% improvement in their knowledge of historical figures."
- "The assistive technology project correctly identifies 95% of common household objects and provides clear audio descriptions to the user."
- "The image recognition model integrates seamlessly with the existing inventory management system and reduces processing time by 15%."

By defining clear, measurable, and relevant success criteria, you effectively guide the development of your Teachable Machine Image Project and ensure it meets your intended goals.

3.2 Data collection and preparation: Building your dataset

Data forms the lifeblood of any Machine Learning model. The quality, quantity, and diversity of your data directly impact the performance and accuracy of your Teachable Machine project. Therefore, planning a robust data collection strategy is essential for building a successful model.

3.2.1 Gathering image data: Sources and methods

The quality and diversity of your image dataset are paramount to the success of your Teachable Machine Image Project. A well-constructed dataset enables your model to learn effectively and

Funded by the European Union

Funded by the European Union. However, the views expressed belong to the author(s) alone and do not necessarily reflect the views of the European Union or the Erasmus+ National Agency -INDIRE. Neither the European Union nor the granting administration can be held responsible for them. Project N°: 2024-1-IT02-KA220-SCH-000249373

make accurate predictions. This section outlines various sources and methods for gathering image data:

- **Webcam capture:** Teachable Machine provides a convenient feature allowing direct image capture using your computer's webcam. This method proves particularly useful for collecting images of objects readily available in your immediate environment.
    - **Advantages:**
        - Data collection is easy and quick.
        - Real-time capture of specific objects or scenes is possible.
        - Control over image lighting, background, and angle is provided.
    - **Considerations:**
        - Availability of objects or environmental limitations may exist.
        - Image quality can depend on the webcam's resolution and lighting conditions.

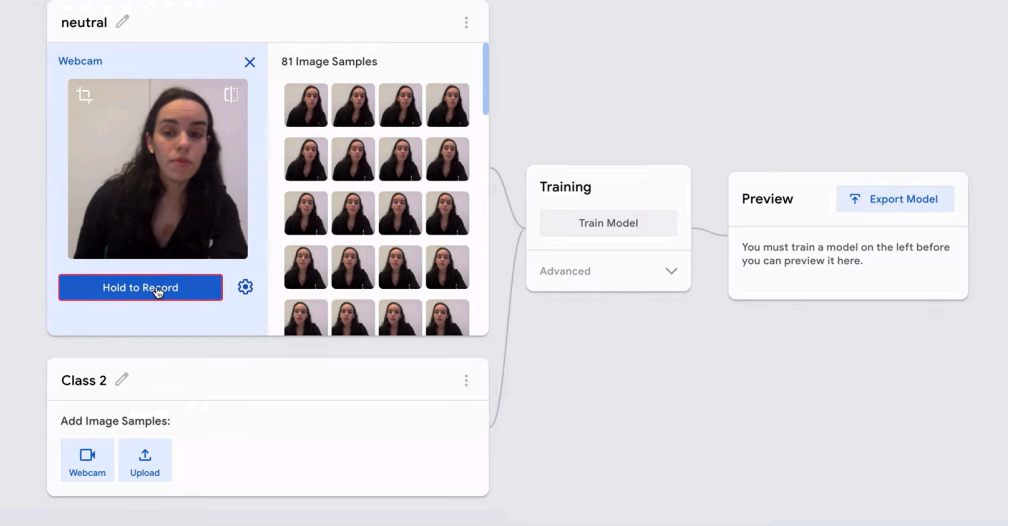


Image 8: Webcam capture

- **Existing image libraries and databases:** Numerous online image libraries and databases offer vast collections of images suitable for your Teachable Machine projects. These resources are particularly helpful for accessing images of objects or concepts not easily captured with a webcam.
    - **Examples of resources:**
        - Unsplash: Provides a collection of high-resolution images free to use.
        - Pexels: Offers a similar collection of free images and videos.

Funded by the European Union

Funded by the European Union. However, the views expressed belong to the author(s) alone and do not necessarily reflect the views of the European Union or the Erasmus+ National Agency -INDIRE. Neither the European Union nor the granting administration can be held responsible for them. Project N°: 2024-1-IT02-KA220-SCH-000249373

- Google Images: Can be used for searching specific images, but be mindful of copyright restrictions.
- Specialized Databases: Depending on your project, specialized databases (e.g., medical image databases, plant databases) may be available.

- **Advantages:**
  - Access to a wide variety of images is granted.
  - Time and effort are saved compared to capturing all images yourself.
  - Access to images of objects or concepts otherwise difficult to obtain is provided.
- **Considerations:**
  - Be mindful of copyright restrictions and usage rights.
  - Image quality and consistency may vary.
  - Careful filtering or selection of images ensures relevance to your project.

- **Personal photo collections:** If you possess a personal collection of photos, some images might be usable for your Teachable Machine project. This can be a good option for collecting images of familiar objects or scenes.
  - **Advantages:**
    - Easy access to an existing image collection.
    - Images are likely relevant to your context.
    - A personal touch is added to your project.
  - **Considerations:**
    - Ensure you have the right to use the images.
    - Image quality and consistency may vary.
    - Careful image selection ensures appropriateness for your project.

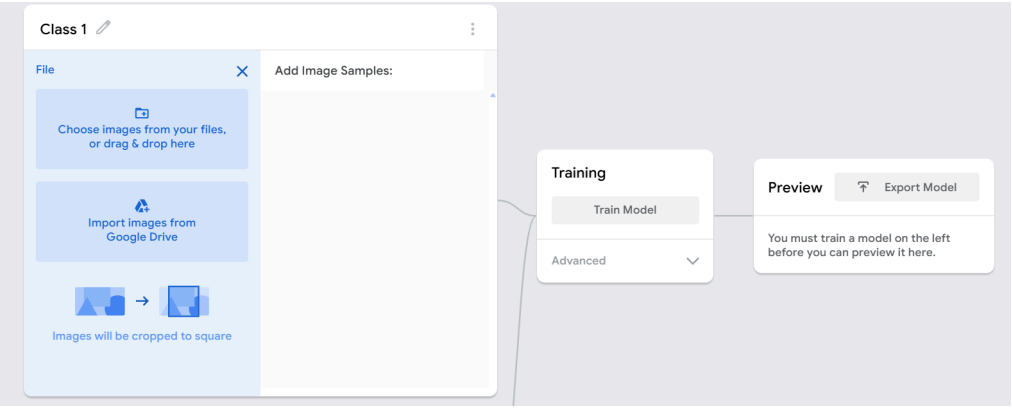


Image 9: Existing images/personal photo upload

Funded by the European Union

Funded by the European Union. However, the views expressed belong to the author(s) alone and do not necessarily reflect the views of the European Union or the Erasmus+ National Agency -INDIRE. Neither the European Union nor the granting administration can be held responsible for them. Project N°: 2024-1-IT02-KA220-SCH-000249373

- **Image augmentation:** This technique involves artificially increasing the size and diversity of your dataset by applying various transformations to existing images. This can be a valuable method for improving your model's performance.
    - **Examples of augmentation techniques:**
        - Rotating images.
        - Flipping images horizontally or vertically.
        - Cropping images.
        - Zooming in or out of images.
        - Adjusting image brightness or contrast.
    - **Advantages:**
        - Increases the size and diversity of your dataset.
        - Can improve your model's ability to generalize and handle image variations.
        - Helps prevent overfitting (when the model learns the training data too well and performs poorly on new data).
    - **Considerations:**
        - Use augmentation techniques judiciously.
        - Ensure transformations are realistic and do not significantly alter image content.

When gathering image data, prioritizing quality, diversity, and relevance is crucial. Ensure your images are clear, focused, and representative of the objects or concepts your model must recognize.

💡 **Pro tip**

Better accuracy (Quality vs. Quantity): Quality and variety are far more important than sheer volume. Instead of capturing 100 identical photos of an object in the exact same spot, take 30 photos from different angles, varying distances, and under different lighting conditions. For example, if training the AI to recognize an apple, include photos of red apples, green apples, and even half-eaten apples so the model learns the true concept rather than a single specific image!

Conceptual focus for students: Emphasize to your students that computers do not truly "see" images as humans do. Instead, the model converts images into numerical pixel matrices and detects mathematical differences between colors, textures, and geometric

Funded by the European Union

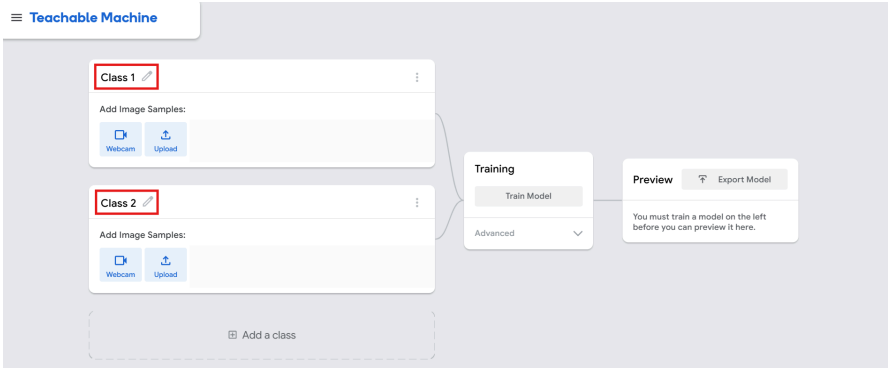
Funded by the European Union. However, the views expressed belong to the author(s) alone and do not necessarily reflect the views of the European Union or the Erasmus+ National Agency -INDIRE. Neither the European Union nor the granting administration can be held responsible for them. Project N°: 2024-1-IT02-KA220-SCH-000249373

shapes to infer predictions.

3.2.2 Creating image classes: Defining categories for your model

In Teachable Machine, "classes" represent the distinct categories or labels your image recognition model learns to identify. Clearly and accurately defining these classes is a crucial step in preparing your dataset and ensuring your model effectively distinguishes between different objects or concepts. Here's a guide to creating image classes:

- **Clearly define your categories:** Before adding images, take time to carefully define the categories your model will recognize. Each class must represent a specific object, concept, or classification relevant to your project goals. Ensure categories are well-defined, unambiguous, and mutually exclusive (to the extent possible). This means minimal overlap or confusion between categories. For example, if classifying fruit, classes might be "apple," "banana," "orange," and "grape".
- **Determine the number of classes:** The number of classes needed depends on your project's complexity and the number of distinct objects or concepts to recognize. Start with a manageable number, especially as a beginner. Additional classes can always be added later if needed. Consider the trade-off between the number of classes and the data required; more classes generally demand more data for effective model training.
- **Name your classes appropriately:** Assign clear, descriptive names to your classes that accurately reflect the objects or concepts they represent. This aids organization and ensures easy understanding of each class's purpose. Use consistent naming conventions, for example, singular nouns (e.g., "apple" instead of "apples") or specific terms (e.g., "red apple" instead of just "apple").



Funded by the European Union

Funded by the European Union. However, the views expressed belong to the author(s) alone and do not necessarily reflect the views of the European Union or the Erasmus+ National Agency -INDIRE. Neither the European Union nor the granting administration can be held responsible for them. Project N°: 2024-1-IT02-KA220-SCH-000249373

Image 10: Defining classes name

- **Create classes in Teachable Machine:** Teachable Machine provides a user-friendly interface for creating and managing classes. An area for adding new classes, renaming existing ones, or deleting classes is available. Follow the on-screen instructions to create your classes and assign appropriate names.

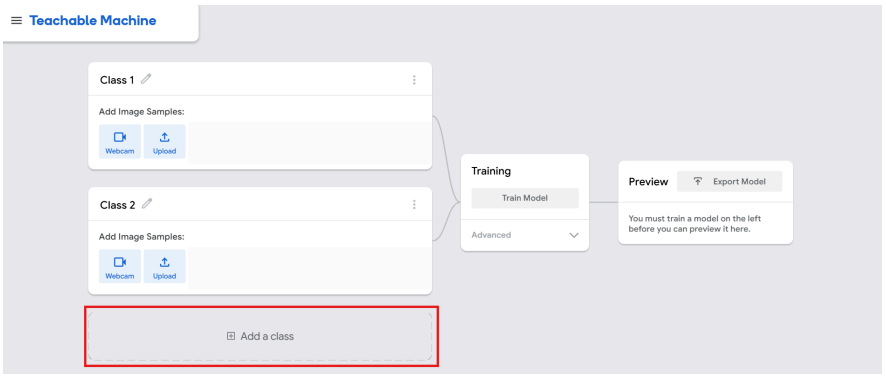


Image 11: Adding new classes

- **Consider hierarchical classification (If applicable):** In some cases, a hierarchical classification system, with broader categories and subcategories, may be desired. For instance, when classifying animals, you might have "mammals," "birds," and "reptiles" as broader classes, then subcategories like "dog," "cat," "cow" within "mammals". While Teachable Machine may not directly support hierarchical classification, a similar effect is achieved by creating more specific classes.
- **Review and refine your classes:** After creating your initial set of classes, carefully review them to ensure appropriateness for your project goals. Consider whether adding, removing, or renaming classes is necessary. Often, refining classes becomes helpful after starting data collection, as a better understanding of data variations is gained.

By carefully defining and creating your image classes, you establish a solid foundation for your Teachable Machine Image Project, ensuring your model effectively learns to distinguish between the specified categories.

Funded by
the European Union

Funded by the European Union. However, the views expressed belong to the author(s) alone and do not necessarily reflect the views of the European Union or the Erasmus+ National Agency -INDIRE. Neither the European Union nor the granting administration can be held responsible for them. Project N°: 2024-1-IT02-KA220-SCH-000249373

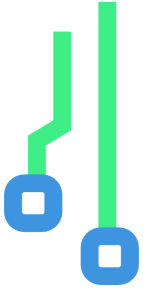
3.2.3 Data augmentation: Enhancing your dataset

Data augmentation is a powerful technique for artificially increasing the size and diversity of your image dataset. This involves applying various transformations to existing images to create new, slightly modified versions. This method can significantly improve your Teachable Machine Image Project's robustness and generalization ability, helping it perform well on unseen data. Here's a guide to data augmentation:

- **Why use data augmentation?**
  - **Increased dataset size:** Augmentation allows the generation of more training data from existing images, effectively expanding your dataset without needing to collect new images. This is particularly useful when original images are limited.
  - **Improved generalization:** By introducing variations in your training data, augmentation helps the model learn more robust features and become less sensitive to specific details in the training images. This enhances the model's ability to generalize to new, unseen images that may differ slightly from the training data.
  - **Reduced overfitting:** Overfitting occurs when a model learns the training data too well, including its noise and idiosyncrasies, leading to poor performance on new data. Augmentation helps prevent overfitting by making the model less reliant on specific training examples and encouraging it to learn more generalizable features.
- **Common augmentation techniques:**
  - **Rotation:** Rotating images by various angles (e.g., 10, 45, 90 degrees) helps the model recognize objects regardless of their orientation.
  - **Flipping:** Flipping images horizontally or vertically assists the model in recognizing objects even if mirrored.
  - **Cropping:** Randomly cropping portions of images helps the model focus on different parts of an object, making it less sensitive to the overall image composition.
  - **Zooming:** Zooming in or out of images allows the model to learn to recognize objects at different scales.
  - **Brightness and contrast adjustments:** Varying image brightness and contrast helps the model become more robust to different lighting conditions.
  - **Color jittering:** Randomly adjusting image color properties (e.g., hue, saturation) helps the model become less sensitive to color variations.

Funded by the European Union

Funded by the European Union. However, the views expressed belong to the author(s) alone and do not necessarily reflect the views of the European Union or the Erasmus+ National Agency -INDIRE. Neither the European Union nor the granting administration can be held responsible for them. Project N°: 2024-1-IT02-KA220-SCH-000249373



    - **Adding noise:** Introducing random noise to images enhances the model's robustness to noisy or imperfect data.
- **Applying data augmentation:**
    - **Teachable Machine's built-in features:** Teachable Machine includes some basic built-in augmentation features. Explore the platform's options for applying simple transformations like flipping or cropping directly within the interface.
    - **External tools and libraries (For advanced exploration):** For more advanced augmentation techniques, external image editing software (e.g., GIMP, Photoshop) or programming libraries (like Python's `ImageDataGenerator` from TensorFlow/Keras or `albumentations`) can be used to apply various transformations programmatically. For primary teachers, focusing on the built-in features is typically sufficient; these external tools are for deeper exploration.
- **Augmentation best practices:**
    - Apply augmentation techniques judiciously. Avoid over-augmenting data to the point where transformed images no longer resemble realistic variations of the originals.
    - Consider your project's specific requirements and choose augmentation techniques relevant to variations your model is likely to encounter.
    - Monitor your model's performance on a validation set (data not used for training) to ensure augmentation improves generalization and does not hinder performance.

By effectively utilizing data augmentation, you enhance the robustness, accuracy, and generalization of your Teachable Machine Image Projects, leading to more reliable and effective image recognition models.

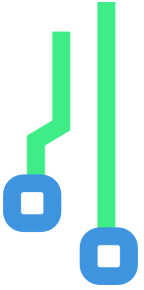
3.2.4 Preparing your data for Teachable Machine

Once your image data is gathered and any desired augmentation techniques applied, the next step involves preparing it for use in Teachable Machine. Proper data preparation ensures your images are in the correct format, organized effectively, and ready for training your ML model. Here's a guide to preparing your data:

- **Image file formats:** Teachable Machine typically supports common image file formats such as:
    - JPEG (.jpg or .jpeg)
    - PNG (.png)

Funded by the European Union

Funded by the European Union. However, the views expressed belong to the author(s) alone and do not necessarily reflect the views of the European Union or the Erasmus+ National Agency -INDIRE. Neither the European Union nor the granting administration can be held responsible for them. Project N°: 2024-1-IT02-KA220-SCH-000249373



    - GIF (.gif) Ensure your images are saved in one of these formats. If other formats are used, conversion via image editing software or online tools may be necessary.
- **Image resolution and size:** While Teachable Machine handles various image resolutions, using images appropriately sized for your project is generally good practice. Very high-resolution images consume more processing power, potentially slowing training. Conversely, very low-resolution images may lack detail for effective model learning. Consider resizing images to a reasonable size before uploading them to Teachable Machine. A common range falls between 224x224 and 512x512 pixels, though optimal size depends on project complexity. Maintaining consistency in image size across your dataset is beneficial.
- **Data organization:** Organize your image files into folders corresponding to the classes defined in Teachable Machine. Create a separate folder for each class and place relevant images within it. This folder structure facilitates easy data upload to Teachable Machine, as entire folders can typically be uploaded at once. Use clear and consistent naming conventions for your image files to ensure logical organization.
- **Data cleaning:** Before uploading, take time to review and clean your image dataset. Remove any irrelevant, inappropriate, corrupted, or damaged image files. If needed, edit images to improve quality or consistency (e.g., cropping, adjusting brightness).
- **Data splitting (Optional but recommended):** For more advanced Machine Learning practices, splitting your dataset into three subsets is recommended:
    - **Training set:** The largest subset, used to train the ML model.
    - **Validation set:** Used to evaluate model performance during training and tune hyperparameters.
    - **Test set:** Used to evaluate the final model's performance after training is complete. Teachable Machine does not require explicit splitting for basic use, but it is a good practice for rigorous model evaluation. A similar effect is achieved by reserving a portion of your data and not using it during the initial training phase. If data splitting is chosen, ensure similar class distribution across all subsets.
- **Uploading data to Teachable Machine:** Once your data is prepared, it is ready for upload to Teachable Machine. The platform provides user-friendly tools for uploading images, typically allowing you to:
    - Upload images individually.
    - Upload entire folders of images.
    - Use your webcam to capture images directly. Follow the on-screen instructions to upload your data and associate it with the correct classes.

Funded by the European Union

Funded by the European Union. However, the views expressed belong to the author(s) alone and do not necessarily reflect the views of the European Union or the Erasmus+ National Agency -INDIRE. Neither the European Union nor the granting administration can be held responsible for them. Project N°: 2024-1-IT02-KA220-SCH-000249373

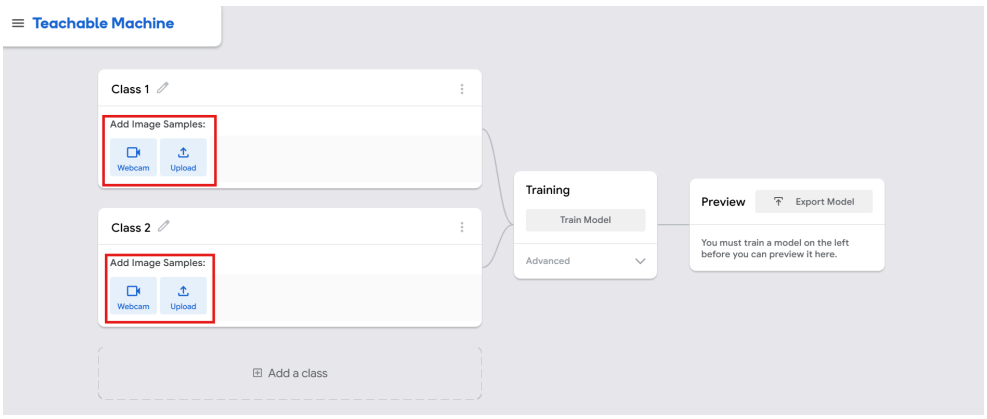


Image 12: Upload data

By carefully preparing your data, you ensure it is in optimal condition for training your Teachable Machine Image Project, leading to better model performance and more reliable results.

3.3 Model training and evaluation: Bringing your AI to life

3.3.1 Training your Image model: Step-by-step

Once your image dataset is prepared, the next step involves training your Machine Learning model in Teachable Machine. The training process entails feeding your data to the model, allowing it to learn and recognize the patterns and features that distinguish between the different classes you have defined. Teachable Machine simplifies this process, making it accessible even to those without coding experience. Here's a step-by-step guide to training your image model:

- **Access your project:** Open Teachable Machine and access the Image Project on which you have been working. Ensure that your image data is uploaded and organized into the correct classes.
- **Review your data:** Before starting the training process, take a moment to review your data. Confirm its accuracy and ensure each class contains a sufficient number of representative images. You can typically browse through the images in each class directly within the Teachable Machine interface.
- **Initiate training:** Teachable Machine provides a clear button or control to start the training process. This is a prominent button labeled "Train Model". Click this button to begin the training.

Funded by the European Union

Funded by the European Union. However, the views expressed belong to the author(s) alone and do not necessarily reflect the views of the European Union or the Erasmus+ National Agency -INDIRE. Neither the European Union nor the granting administration can be held responsible for them. Project N°: 2024-1-IT02-KA220-SCH-000249373

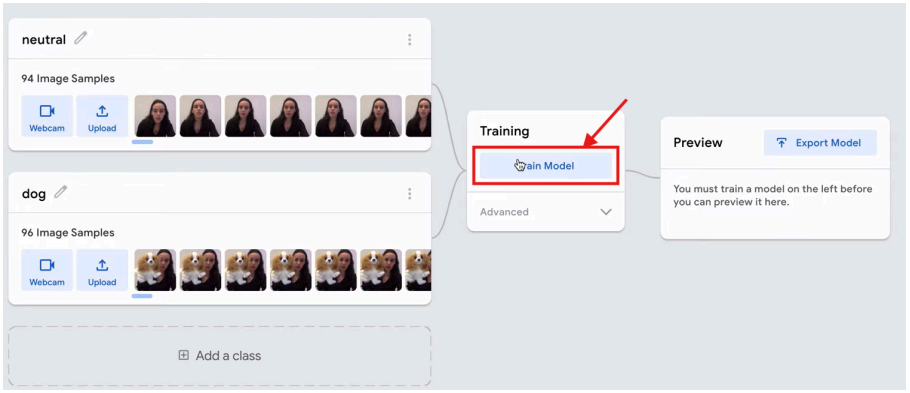


Image 12: Initiate training.

- **Training process:** Once you initiate training, Teachable Machine begins processing your image data. The platform utilizes Machine Learning algorithms to analyze the images and identify key features distinguishing between classes. During training, the model adjusts its internal parameters to optimize its ability to classify images correctly. Teachable Machine provides visual feedback on the training progress. This includes progress bars, messages, or animations indicating that training is underway. The duration of the training process depends on your dataset's size and complexity, as well as your computer's processing power or the platform's servers.

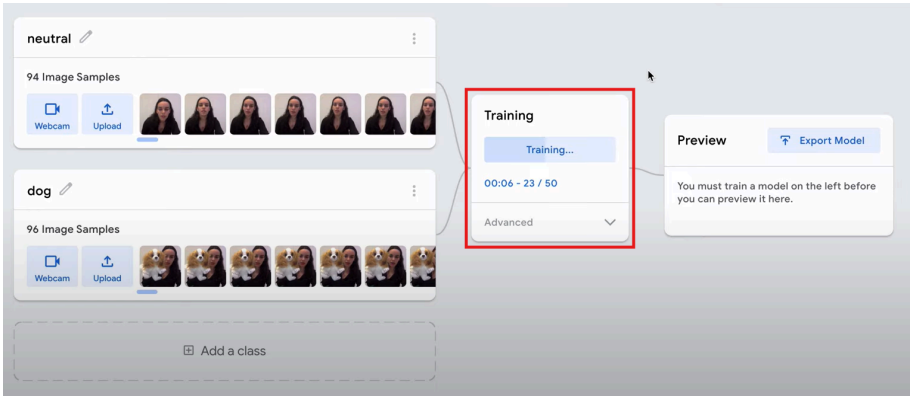
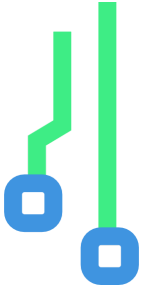


Image 13: Training process.

- **No coding required:** A key advantage of Teachable Machine is its handling of complex model training computations in the background. You do not need to write any code or possess specialized knowledge of Machine Learning algorithms to train your model.
- **Advanced training settings (Optional for deeper exploration):** While designed for simplicity, Teachable Machine offers "Advanced Settings" that allow users to fine-tune

Funded by the European Union

Funded by the European Union. However, the views expressed belong to the author(s) alone and do not necessarily reflect the views of the European Union or the Erasmus+ National Agency -INDIRE. Neither the European Union nor the granting administration can be held responsible for them. Project N°: 2024-1-IT02-KA220-SCH-000249373



the training process. These settings can influence how the model learns and its final performance. The availability and specific nature of these settings might vary slightly with Teachable Machine platform updates.

- **Epochs:** An epoch represents one complete pass through the entire training dataset during the training process. Increasing epochs generally allows more thorough learning, but also raises the risk of overfitting (where the model performs well on training data but poorly on new data). Teachable Machine allows epoch adjustment, providing control over training duration.

> 💡 **Teacher's analogy:**
>
> Think of epochs as "practice rounds." 50 epochs means the AI reviews your training photos 50 times. If the AI is still making mistakes during preview, try increasing this setting to 100 rounds.

- **Batch size:** This refers to the number of data samples (images, in this case) the model processes at a time during each parameter update. Adjusting batch size affects training speed and learning dynamics. Teachable Machine offers options for different batch sizes.
- **Learning rate:** A crucial parameter, the learning rate controls the step size the model takes to update its parameters based on calculated error (loss). A learning rate that is too high causes divergence and learning failure, while one that is too low significantly slows the training process. While Teachable Machine simplifies many aspects, advanced machine learning workflows involve this rate. If available as an option, proceed with caution.
- **Other hyperparameters:** Machine learning models possess parameters called hyperparameters that control the learning process. Teachable Machine exposes some of these for adjustment. Tuning these often requires experimentation and an understanding of machine learning principles.
- **Using advanced settings:** If choosing to use advanced settings, a systematic approach is generally recommended. Change one setting at a time, observe its impact on model performance, and meticulously track experiments and results. Effective use often demands a deeper understanding of machine learning

Funded by the European Union

Funded by the European Union. However, the views expressed belong to the author(s) alone and do not necessarily reflect the views of the European Union or the Erasmus+ National Agency -INDIRE. Neither the European Union nor the granting administration can be held responsible for them. Project N°: 2024-1-IT02-KA220-SCH-000249373

concepts. For those new to machine learning, starting with default settings and gradually exploring advanced options as experience is gained is advisable.

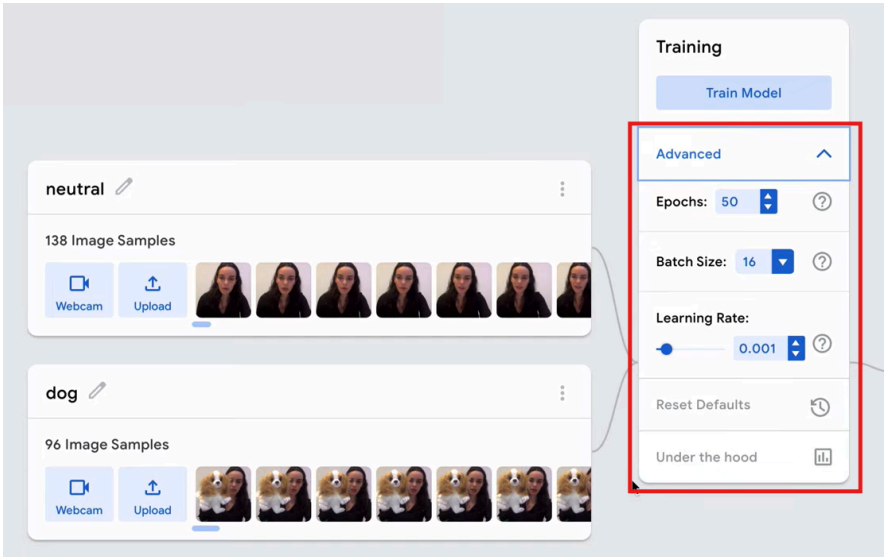


Image 14: Advance training settings.

- **Training tips:**
  - **Start with sufficient data:** Ensure adequate data in each class before training. A balanced dataset with a reasonable number of images per class generally yields better results.
  - **Monitor progress (If available):** If Teachable Machine provides feedback on training progress, monitor it to understand how the model learns.
  - **Iterative training:** Training the model multiple times may be necessary, especially if initial results are unsatisfactory. Adjust your dataset, add more data, or modify classes, then retrain the model.
- **Completion of training:** Once the training process concludes, Teachable Machine notifies you. Your image recognition model is now trained and ready for evaluation and use.

Teachable Machine simplifies the training process, making it accessible to a wide range of users. By following these steps and ensuring a well-prepared dataset, you effectively train your image model and begin exploring its capabilities.

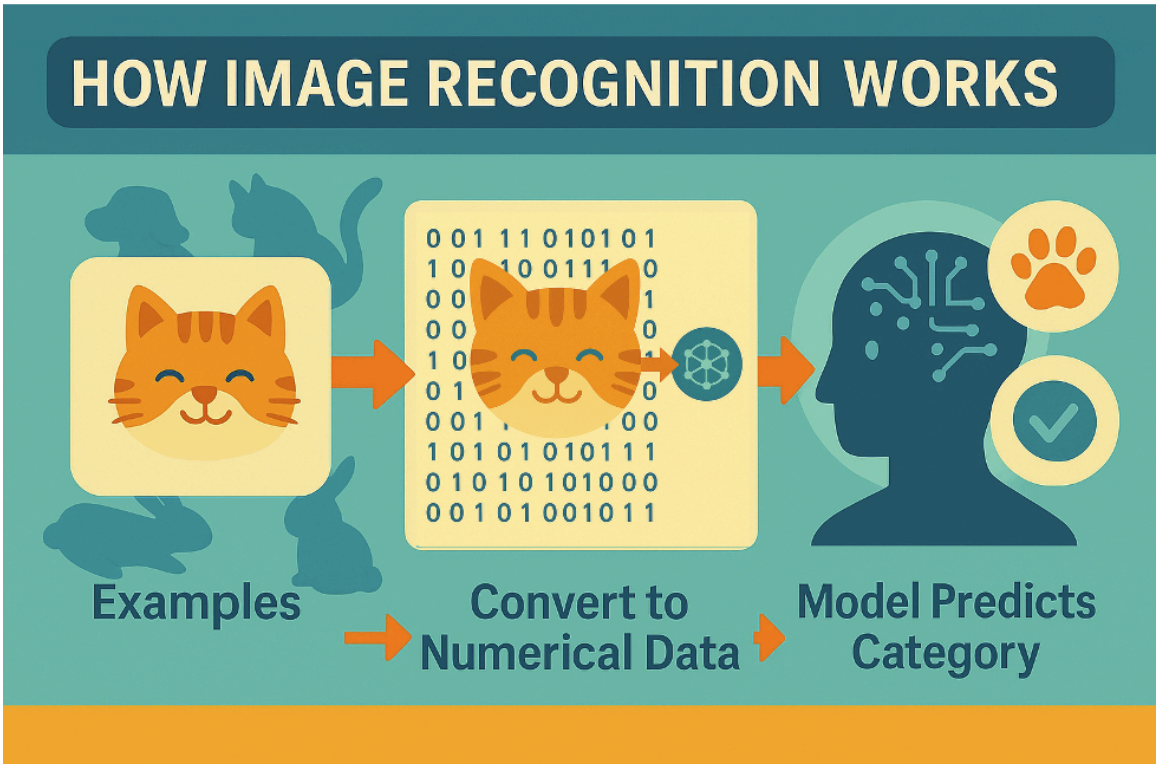
Funded by the European Union

Funded by the European Union. However, the views expressed belong to the author(s) alone and do not necessarily reflect the views of the European Union or the Erasmus+ National Agency -INDIRE. Neither the European Union nor the granting administration can be held responsible for them. Project N°: 2024-1-IT02-KA220-SCH-000249373

M{AI}L

How image recognition works (Simplified):

Machine Learning for images relies on large sets of examples. Each image is converted into numerical data (pixels) that the model analyzes to find recurring patterns. After training, the model predicts which category a new image belongs to based on what it has learned.



🧠 Simplified process				
				
1. Collect Examples	2. Train	3. Evaluate	4. Test new images	5. Improve with feedback

Teachers should emphasize that computers do not truly ‘see’ images but rather detect mathematical differences between colors, textures, and shapes.

Funded by the European Union

Funded by the European Union. However, the views expressed belong to the author(s) alone and do not necessarily reflect the views of the European Union or the Erasmus+ National Agency -INDIRE. Neither the European Union nor the granting administration can be held responsible for them. Project N°: 2024-1-IT02-KA220-SCH-000249373

3.3.2 Evaluating model performance: Understanding accuracy and metrics

After training your image model in Teachable Machine, evaluating its performance is crucial to determine how well it works and whether it meets your project's success criteria. Evaluation involves testing the model with data it has not seen during training and analyzing its predictions. Here's a guide to evaluating model performance:

- **Teachable Machine's preview:** A built-in preview feature in Teachable Machine allows quick testing of your trained model. You can use your webcam to capture new images or upload existing ones, then observe how the model classifies them. This preview offers an intuitive way to gauge your model's performance quickly. Observe if the model correctly identifies objects or concepts in the images provided. Pay attention to any misclassifications or instances where the model appears uncertain.

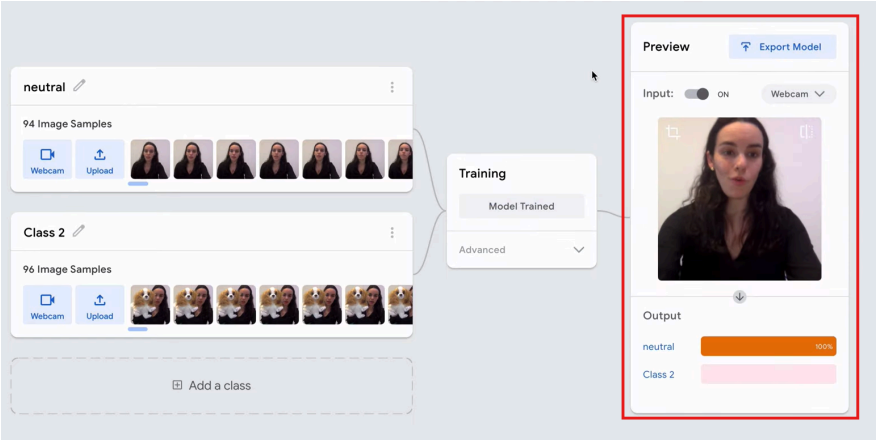


Image 15: Preview feature.

- **Understanding accuracy:** Accuracy stands as a common metric for evaluating classification models. It represents the overall proportion of correct predictions made by the model. For example, if you provide the model with 100 test images and it correctly classifies 90, the accuracy is 90%. While accuracy is a useful metric, its limitations, especially with imbalanced datasets (where some classes have significantly more data than others), are important to consider.
- **Confusion matrix:** A confusion matrix provides a more detailed breakdown of your model's performance. This table shows the number of correct and incorrect predictions for each class. The rows typically represent the actual classes, while the columns

Funded by the European Union

Funded by the European Union. However, the views expressed belong to the author(s) alone and do not necessarily reflect the views of the European Union or the Erasmus+ National Agency -INDIRE. Neither the European Union nor the granting administration can be held responsible for them. Project N°: 2024-1-IT02-KA220-SCH-000249373

represent the predicted classes. Analyzing the confusion matrix helps identify which classes the model struggles to distinguish and where it makes the most errors.

- **Precision and recall (Simplified):** Other important metrics, precision and recall, offer a nuanced understanding of your model's performance, particularly with imbalanced datasets.
    - **Precision:** Measures the proportion of positive identifications that were actually correct. It answers: "Of all the times the model said it was a certain class, how often was it right?".
    - **Recall:** Measures the proportion of actual positives that were correctly identified by the model. It answers: "Of all the times it *actually* was a certain class, how often did the model say so?". A high precision score indicates the model excels at avoiding false positives, while a high recall score signifies it is good at identifying all instances of a particular class.
- **F1-score (Simplified):** The F1-score combines precision and recall into a single value. It provides a balanced measure of a model's performance, especially when an imbalance exists between classes. Generally, a higher F1-score indicates better performance.
- **Evaluation best practices:**
    - **Use a separate test set:** For an unbiased evaluation, testing your model on data it has not encountered during training is crucial. This is known as a test set.
    - **Evaluate on representative data:** Ensure your test data accurately represents the real-world data your model will encounter.
    - **Consider your project goals:** The most important metrics for evaluating your model depend on your project's specific goals. If avoiding false positives is critical, prioritize precision. If identifying all instances of a class is crucial, prioritize recall.
    - **Iterative evaluation:** Evaluation is an iterative process. You may need to evaluate your model multiple times, adjust your dataset or training process, and then re-evaluate to see if changes have improved performance.

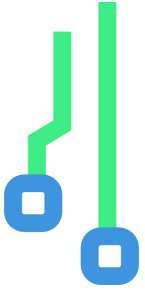
By carefully evaluating your model's performance using appropriate metrics and best practices, you gain a clear understanding of its strengths and weaknesses and make informed decisions on how to improve it.

3.3.3 Troubleshooting and improving your model

Encountering challenges and areas for improvement is common when training and evaluating your Teachable Machine Image Project. Your model might not perform as expected initially, or

Funded by the European Union

Funded by the European Union. However, the views expressed belong to the author(s) alone and do not necessarily reflect the views of the European Union or the Erasmus+ National Agency -INDIRE. Neither the European Union nor the granting administration can be held responsible for them. Project N°: 2024-1-IT02-KA220-SCH-000249373



you might notice specific weaknesses in its predictions. Troubleshooting and iteratively improving your model are essential parts of the Machine Learning process. Here's a guide to help you:

- **Identify common problems:**
  - **Low accuracy:** The model makes a large number of incorrect predictions.
  - **Overfitting:** The model performs well on the training data but poorly on new, unseen data. This indicates that the model has learned the training data too well, including its noise and idiosyncrasies.

💡**Quick classroom diagnosis:**

Why is my image model failing?

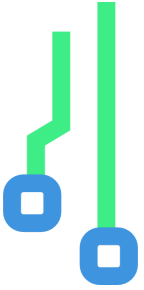
Background noise: Check if the AI is focusing on the object or on the background (e.g., a messy bookshelf or a bright window behind you). Try capturing data against a plain, neutral background.

Overfitting to the demonstrator: If the AI only recognizes an object when the teacher holds it, but fails when a student holds it, the model has learned your hand instead of the object. Add photos with different hands and backgrounds to fix this.

  - **Confusion between classes:** The model struggles to distinguish between certain classes, often misclassifying images from one class as another.
  - **Bias:** The model performs significantly better on some groups or categories than others, indicating potential bias in the data or model.
- **Strategies for troubleshooting and improvement:**
  - **Increase data quantity:** If your model exhibits low accuracy, a common solution involves increasing the amount of training data. Collect more images for each class, ensuring a balanced dataset. A larger dataset provides the model with more information to learn from, improving its generalization ability.
  - **Improve data quality and diversity:** Review your existing data to identify any low-quality or unrepresentative images. Replace blurry, distorted, or irrelevant images with clearer, more focused ones. Increase your dataset's diversity by

Funded by the European Union

Funded by the European Union. However, the views expressed belong to the author(s) alone and do not necessarily reflect the views of the European Union or the Erasmus+ National Agency -INDIRE. Neither the European Union nor the granting administration can be held responsible for them. Project N°: 2024-1-IT02-KA220-SCH-000249373



capturing images from different angles, in various lighting conditions, and with different backgrounds. Apply data augmentation techniques to artificially increase data diversity.

- **Refine your classes:** If your model confuses certain classes, review your class definitions to ensure clarity and distinctiveness. If necessary, merge similar classes or create more specific sub-classes to reduce ambiguity. Ensure images within each class are representative and do not significantly overlap with other classes.
- **Address everfitting:** When your model is overfitting, consider these approaches:
  - Data augmentation: As mentioned previously, augmentation helps prevent overfitting.
  - Simplify the model (If applicable): While Teachable Machine abstracts much of the model architecture, in more advanced ML, simplifying the model sometimes helps with overfitting.
  - Early stopping (IfaAvailable): Some training systems incorporate "early stopping," where training halts when performance on a validation set begins to degrade.
- **Check for bias:** Carefully analyze your dataset for potential sources of bias. Ensure your data represents the population your model is intended to serve. If bias is identified, collect more data to balance your dataset and mitigate the bias. Evaluate your model's performance across different groups and categories to identify and address any disparities.
- **Iterative training and evaluation:** Troubleshooting and improvement are iterative processes. Make small changes to your dataset, training process, or class definitions, then retrain and re-evaluate your model. Meticulously track the changes made and their impact on performance. Use evaluation metrics (accuracy, precision, recall, confusion matrix) to guide your improvements.
- **Seek help and resources:** If you struggle to improve your model's performance, do not hesitate to seek help and resources. Online forums, tutorials, and communities offer valuable insights and guidance. Teachable Machine's documentation and support resources also provide helpful tips and troubleshooting advice.

By systematically troubleshooting and iteratively improving your model, you overcome challenges, enhance its performance, and achieve desired results in your Teachable Machine Image Projects.

Funded by the European Union

Funded by the European Union. However, the views expressed belong to the author(s) alone and do not necessarily reflect the views of the European Union or the Erasmus+ National Agency -INDIRE. Neither the European Union nor the granting administration can be held responsible for them. Project N°: 2024-1-IT02-KA220-SCH-000249373

3.4 Applications in the classroom: Image AI in action

3.4.1 Interactive learning activities with image recognition

Image recognition technology, powered by Teachable Machine, serves as a valuable tool for creating engaging and interactive learning activities in the classroom. Incorporating image-based AI into your lessons provides students with hands-on experiences, enhances their understanding of concepts, and fosters a more dynamic learning environment. Here are some examples of interactive learning activities with image recognition:

- **Image-based scavenger hunts:** Create a scavenger hunt activity where students utilize a Teachable Machine model to identify specific objects or items within their classroom, school, or outdoor environment. Students can use a tablet or smartphone equipped with the Teachable Machine model to scan their surroundings, searching for designated items. This activity promotes observation skills, encourages exploration, and makes learning more active and enjoyable. For instance, younger students might search for different shapes, colors, or leaf types, while older students could identify historical artifacts, architectural details, or scientific specimens.
- **Interactive flashcards:** Developing interactive flashcards that use image recognition is an effective way to check students' understanding of concepts. Instead of simply displaying a word or definition, these flashcards present an image, and students then use a Teachable Machine model to identify or classify it. This proves particularly useful in subjects like science, where students can identify animals, plants, or anatomical structures, or for language learning, where they recognize objects and associate them with vocabulary words. The interactive nature of these flashcards makes learning more engaging and provides immediate feedback to students.
- **Image-driven storytelling:** Image recognition can spark creativity and storytelling activities. Students can utilize a Teachable Machine model to identify objects or characters within a series of images, subsequently using those elements to construct a story. This activity enhances students' imagination, language skills, and narrative abilities. For example, students could use images of different animals to create a story about a jungle adventure, or historical figures' images to write a fictional account of a historical event.
- **Virtual Tours and explorations:** Create virtual tours or explorations that leverage image recognition to provide students with information about different locations or objects. Students can use a Teachable Machine model to scan images of landmarks, museum

Funded by the European Union

Funded by the European Union. However, the views expressed belong to the author(s) alone and do not necessarily reflect the views of the European Union or the Erasmus+ National Agency -INDIRE. Neither the European Union nor the granting administration can be held responsible for them. Project N°: 2024-1-IT02-KA220-SCH-000249373

exhibits, or natural environments and access related information, videos, or audio clips. This activity offers immersive learning experiences, allowing students to explore places they might not otherwise visit. For example, students could take a virtual tour of a historical site, scanning images of buildings or artifacts to learn about their history, or explore a virtual museum, scanning artworks to learn about artists and techniques.

- **Image-based problem solving:** Present students with image-based problems or challenges requiring them to use a Teachable Machine model to find solutions. For instance, students might use a model to identify damaged parts in an image of a machine, or classify different types of pollution in an environmental image. This activity develops students' critical thinking, problem-solving skills, and ability to apply knowledge to real-world scenarios.
- **Personalized learning experiences:** Image recognition can contribute to creating personalized learning experiences that adapt to students' individual needs and learning styles. For example, a Teachable Machine model could track students' progress in identifying objects or concepts, providing customized feedback or additional resources. This approach caters to different learning paces and offers targeted student support.

These interactive learning activities demonstrate image recognition's potential to transform the classroom experience, making it more engaging, interactive, and effective.

3.4.2 Integrating image AI into subject-specific lessons

Teachable Machine's image recognition capabilities integrate seamlessly into a wide range of subject-specific lessons, enriching the curriculum and providing students with unique learning experiences. By tailoring image AI projects to specific subjects, educators enhance student engagement, promote deeper understanding, and foster interdisciplinary learning. Here are some examples of how to integrate image AI into different primary school subjects:

- **Life and physical sciences:**
    - **Biology:** Projects can be created that classify different types of plants (e.g., leaves, flowers), animals (e.g., local wildlife, pets), fungi, or even microorganisms from magnified images. Students might collect images of specimens in the field or utilize existing images from textbooks or online resources. Image recognition aids in identifying different life cycle stages, analyzing cell structures (if using appropriate magnifications), or classifying organisms based on their characteristics.

Funded by the European Union

Funded by the European Union. However, the views expressed belong to the author(s) alone and do not necessarily reflect the views of the European Union or the Erasmus+ National Agency -INDIRE. Neither the European Union nor the granting administration can be held responsible for them. Project N°: 2024-1-IT02-KA220-SCH-000249373

- **Earth science:** Projects can be developed that classify different types of rocks, minerals, clouds, or weather patterns. Students can collect images of geological samples or weather phenomena, using image recognition to identify and categorize them. Image AI can further analyze satellite images, identify landforms, or track environmental changes.
- **Astronomy:** Create projects that classify various celestial objects, such as stars, planets, galaxies, or nebulae. Students use images from telescopes or space probes to identify and classify these objects. Image recognition helps analyze astronomical images, identify constellations, or track celestial body movement.

- **Language Arts and Communication:**
  - **Visual vocabulary building:** Projects can be developed that associate images with vocabulary words in a target language. Students use images to learn new words, improve vocabulary, or practice language skills. Image recognition facilitates creating interactive flashcards, picture dictionaries, or language learning games.
  - **Character and setting recognition:** Create projects that recognize and identify characters, objects, or settings from literature or stories. Students use images from book illustrations or self-created drawings to learn about traits, roles, or relationships in the narrative. Image AI can generate interactive character profiles or story summaries.
- **History and Social studies:**
  - **Artifact analysis:** Projects can be developed that identify and classify historical artifacts, such as tools, weapons, pottery, or clothing. Students use images of artifacts from museums or archaeological sites to learn about different cultures and historical periods. Image recognition can analyze artifact style, materials, or function.
  - **Historical figures and landmarks:** Create projects that recognize and identify historical figures from portraits or photographs, or classify historical landmarks (buildings, monuments, archaeological sites). Students use these images to learn about historical significance, architectural features, or cultural context.
- **Visual arts and design:**
  - **Art style classification:** Projects can be created that classify different art styles, such as painting, sculpture, or architecture. Students use images of artworks to learn about the characteristics, techniques, or historical context of different styles. Image recognition can analyze composition, color palette, or subject matter.

Funded by the European Union

Funded by the European Union. However, the views expressed belong to the author(s) alone and do not necessarily reflect the views of the European Union or the Erasmus+ National Agency -INDIRE. Neither the European Union nor the granting administration can be held responsible for them. Project N°: 2024-1-IT02-KA220-SCH-000249373

- **Artist recognition:** Develop projects that recognize and identify different artists from their artworks. Students use images of artworks to learn about artists' lives, influences, or artistic development. Image AI can generate interactive art quizzes or artist biographies.

These examples illustrate image AI's versatility in education, demonstrating its adaptability to enhance learning across various subjects. Integrating Teachable Machine Image Projects into subject-specific lessons allows educators to create engaging, interactive, and effective learning experiences for their students.

Summary table: Cross-curricular Image projects at a glance:

Subject	Classroom project idea	Learning goal
Life and Physical sciences	Classify plant leaves, cloud types, rocks, micro-organisms, or celestial bodies.	Identify species characteristics, analyze geological samples, and study weather patterns or space.
Language arts and Communication	Associate images with target-language words, or recognize story characters and settings.	Reinforce vocabulary acquisition through visual AI feedback.
History and Social studies	Identify museum artifacts, historical figures from portraits, or landmark architecture.	Explore ancient cultures, analyze historical significance, and study architectural styles.
Visual arts and design	Classify art styles (painting, sculpture) or recognize specific artists by their work.	Analyze visual compositions, color palettes, brushstroke techniques, and art history.

3.4.3 Assessment strategies using image-based AI projects

Image-based AI projects, created with Teachable Machine, serve as valuable tools for various assessment strategies to evaluate student learning, provide feedback, and track progress. These

Funded by the European Union

Funded by the European Union. However, the views expressed belong to the author(s) alone and do not necessarily reflect the views of the European Union or the Erasmus+ National Agency -INDIRE. Neither the European Union nor the granting administration can be held responsible for them. Project N°: 2024-1-IT02-KA220-SCH-000249373

projects offer unique opportunities for authentic assessment, allowing students to demonstrate understanding and skills in practical and engaging ways. Here are some examples of assessment strategies using image-based AI projects:

- **Project-based assessment:** Assigning image-based AI projects as a major assessment task requires students to design, develop, and evaluate their own image recognition models. Assess students' understanding of concepts and skills involved, such as data collection, model training, evaluation, and application. Evaluate the quality of their projects, including model accuracy, functionality, and creativity. Provide opportunities for students to present their projects, explaining design choices and findings. Project-based assessment allows for a holistic evaluation of student learning and provides them with a sense of ownership over their work.
- **Performance-based assessment:** Utilizing image-based AI projects assesses students' ability to apply knowledge and skills in practical situations. Present students with real-world scenarios or challenges requiring them to use their models for problem-solving or decision-making. Evaluate their performance based on model prediction accuracy and effectiveness, as well as their ability to interpret and utilize results. For example, students could use a model to identify plant diseases and recommend treatments, or classify different pollution types and propose environmental remediation solutions.
- **Formative assessment:** Image-based AI projects can be integrated into formative assessment activities to monitor student learning and provide ongoing feedback. Use Teachable Machine models to create interactive quizzes, games, or activities allowing students to check understanding of concepts. Provide students with immediate feedback on responses and identify areas needing additional support. Formative assessment with image AI helps students track progress and identify areas for improvement.
- **Self-assessment and peer assessment:** Encourage students to use image-based AI projects for self-assessment and peer assessment. This promotes metacognition, critical thinking, and collaboration skills. Students use their models to evaluate their own understanding or provide feedback to classmates on projects. Provide students with clear criteria and guidelines for self-assessment and peer assessment.
- **Portfolio assessment:** Include image-based AI projects in student portfolios to showcase their learning and achievements over time. Portfolios offer a comprehensive view of student growth and development, highlighting strengths, skills, and progress. Students select their best projects for inclusion and reflect on their learning experiences.

Examples of assessment tasks:

Funded by the European Union

Funded by the European Union. However, the views expressed belong to the author(s) alone and do not necessarily reflect the views of the European Union or the Erasmus+ National Agency -INDIRE. Neither the European Union nor the granting administration can be held responsible for them. Project N°: 2024-1-IT02-KA220-SCH-000249373

- "Design an image recognition model that classifies different types of clouds and use it to predict weather patterns."
- "Develop an image-based quiz testing students' knowledge of historical figures and their contributions."
- "Create a performance-based assessment where students use an image recognition model to identify plant diseases and recommend appropriate treatments."
- "Use a Teachable Machine model to create an interactive activity helping students learn new vocabulary words in a foreign language."

By incorporating image-based AI projects into a variety of assessment strategies, educators create authentic, engaging, and effective ways to evaluate student learning and promote deeper understanding.

📝**Note:**

Once an Image model is trained, students can click "Export Model" and choose the "Sharable Link" option. This generates a public URL that lets students send their working AI model to the teacher or classmates. Anyone with the link can test the model on their own device's webcam without needing to retrain it from scratch!

Funded by the European Union

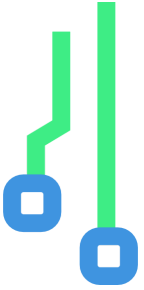
Funded by the European Union. However, the views expressed belong to the author(s) alone and do not necessarily reflect the views of the European Union or the Erasmus+ National Agency -INDIRE. Neither the European Union nor the granting administration can be held responsible for them. Project N°: 2024-1-IT02-KA220-SCH-000249373

M{AI}L

Module 4: Creating Audio Projects

Funded by the European Union. However, the views expressed belong to the author(s) alone and do not necessarily reflect the views of the European Union or the Erasmus+ National Agency -INDIRE. Neither the European Union nor the granting administration can be held responsible for them. Project N°: 2024-1-IT02-KA220-SCH-000249373

Funded by
the European Union



Beyond image recognition, Teachable Machine extends its capabilities to audio. This module guides you through the process of developing Machine Learning models that can recognize and classify different sounds, voices, or musical patterns. Understanding how to create Audio Projects opens up new avenues for interactive learning in your classroom.

4.1 Project planning: Defining your Audio-based AI

Careful planning and preparation are crucial steps before beginning your first Audio Project in Teachable Machine. These initial stages involve defining the project's scope, identifying suitable applications, and establishing clear success criteria.

4.1.1 Identifying classroom applications for Audio recognition

Audio recognition, powered by Machine Learning, presents numerous opportunities to enrich teaching and learning in the classroom. This technology creates interactive sound-based experiences, automates tasks involving audio input, and helps students explore the world through sound in new ways. Here are some examples of classroom applications for audio recognition:

- **Sound identification and classification:** Audio recognition proves useful for building Stools that help students identify and classify sounds. This application is particularly valuable in subjects like science (e.g., identifying animal sounds, different weather sounds like thunder or rain, or sounds of various materials) or music (recognizing instrument sounds). For example, students could develop a project identifying different bird calls or classifying sounds associated with specific environments (e.g., forest, city). This activity enhances students' listening skills, critical thinking about sound properties, and understanding of acoustic environments.
- **Voice command and interaction:** Integrating audio recognition enables interactive activities where students use their voice to command a system or interact with digital content. Teachers, for instance, can create a system where students say a word, and the system responds with a definition, or a game where voice commands control on-screen characters. This makes learning highly interactive and can support students with different learning styles.
- **Language learning and pronunciation practice:** Audio recognition offers significant benefits for language acquisition. Students could create projects that identify and provide feedback on the pronunciation of words or phrases in a new language. This provides immediate, personalized feedback, assisting students in refining their speaking skills. For

Funded by the European Union

Funded by the European Union. However, the views expressed belong to the author(s) alone and do not necessarily reflect the views of the European Union or the Erasmus+ National Agency -INDIRE. Neither the European Union nor the granting administration can be held responsible for them. Project N°: 2024-1-IT02-KA220-SCH-000249373

example, a model could be trained to distinguish between correct and incorrect pronunciations of target vocabulary.

- **Music education:** Explore applications in music education using audio recognition. Students might create projects that recognize different musical notes, chords, or instruments. This fosters an understanding of musical elements and can support interactive music composition or appreciation activities.
- **Assistive technologies:** Audio recognition can be utilized to develop assistive technologies for students with hearing impairments or other special needs. A project, for example, might help identify common environmental sounds (like a doorbell or phone ringing) and provide visual alerts, or assist students with speech impediments by recognizing vocal patterns. This application promotes inclusivity and provides personalized student support.
- **Enhancing storytelling and creative arts:** Integrate audio recognition into creative arts and storytelling activities. Students could use a Teachable Machine model to trigger different sounds or music based on their vocalizations or environmental noises, creating interactive soundscapes or enhancing narrative experiences. This boosts creativity and explores multimodal expression.

These examples represent just a few of the many classroom applications for audio recognition. The possibilities are vast, limited only by the creativity and ingenuity of educators and students.

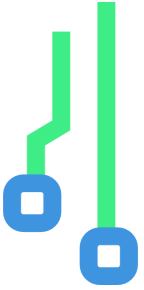
4.1.2 Choosing appropriate sounds or voice patterns for classification

Selecting the right sounds or voice patterns for your Audio Project is crucial for ensuring its success and educational value. Your choices directly influence the project's complexity, the feasibility of data collection, and its relevance to your learning objectives. Here are some key considerations for choosing appropriate sounds or voice patterns for classification in Teachable Machine:

- **Simplicity and distinguishability:** Begin with sounds or voice patterns that are acoustically distinct and easy to differentiate. Avoid categories that sound too similar or possess subtle differences, as these might prove difficult for the model to learn. For instance, instead of trying to distinguish between different types of dog barks (which can be challenging due to variations), start with something simpler, such as classifying animal sounds from different species (e.g., a dog bark, a cat meow, a bird chirp). As students gain experience, they can gradually advance to more complex classification tasks.

Funded by the European Union

Funded by the European Union. However, the views expressed belong to the author(s) alone and do not necessarily reflect the views of the European Union or the Erasmus+ National Agency -INDIRE. Neither the European Union nor the granting administration can be held responsible for them. Project N°: 2024-1-IT02-KA220-SCH-000249373



- **Relevance to learning objectives:** Choose sounds or voice patterns that align directly with your specific learning objectives and curriculum goals. Select categories that will help students acquire new information, develop specific skills, or explore relevant topics. For example, in a science lesson about ecosystems, students could create a project classifying sounds of different animals found in a specific habitat. If teaching a language lesson, students might create a project identifying different vowel sounds or common phrases. Ensure the project supports and enhances the overall learning experience.
- **Feasibility of data collection:** Consider the ease and practicality of collecting sufficient data for your chosen sounds or voice patterns. Select categories for which a diverse and representative dataset can be readily obtained. If planning to record audio using a microphone, choose sounds easily reproducible or recordable within your classroom or learning environment. If using existing audio, ensure access to a suitable collection online or from other resources. Avoid categories that are difficult to capture, require specialized recording equipment, or are ethically sensitive (e.g., private conversations).
- **Clarity of categories:** Define clear and unambiguous categories for your project. Ensure minimal overlap or ambiguity exists between these categories. Each category must represent a distinct and well-defined sound or voice pattern. Avoid categories that are too broad or easily confused with one another. For example, instead of broad categories like "music" and "speech," opt for distinct categories like "classical music," "pop music," and "children's speech."
- **Student engagement and interest:** Choose sounds or voice patterns likely to engage and interest your students. Select categories relevant to their lives, hobbies, or interests. Student interest in a project often translates to higher motivation for participation and learning. Consider involving students in the selection process by brainstorming ideas together and allowing them to choose appealing categories.
- **Ethical considerations:** Always be mindful of any ethical considerations related to your chosen sounds or voice patterns. Avoid categories that could be offensive, discriminatory, or harmful. If working with voice data, ensure appropriate consent is obtained and privacy is protected. Choose categories that promote positive values and responsible use of technology.

By carefully considering these factors, you select appropriate sounds or voice patterns for your Teachable Machine Audio Projects, ensuring they are educationally valuable, engaging, and ethically sound.

Funded by the European Union

Funded by the European Union. However, the views expressed belong to the author(s) alone and do not necessarily reflect the views of the European Union or the Erasmus+ National Agency -INDIRE. Neither the European Union nor the granting administration can be held responsible for them. Project N°: 2024-1-IT02-KA220-SCH-000249373

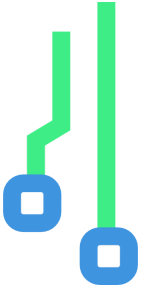
4.1.3 Defining project success criteria

Establishing clear success criteria before you begin your Teachable Machine Audio Project is crucial for evaluating its effectiveness and determining whether it has achieved its intended purpose. Success criteria provide a benchmark against which you can measure your project's performance and identify areas for improvement. They also help maintain focus during the development process and ensure you remain on track to achieve your goals. Here's a guide to defining effective project success criteria for audio projects:

- **Accuracy and performance metrics:** Setting targets for your audio recognition model's accuracy and performance is a common way to define success.
    - **Overall accuracy:** Determine the minimum acceptable percentage of correct classifications. For instance, a goal might be to achieve 90% overall accuracy, meaning the model correctly classifies 90% of the audio samples presented to it.
    - **Class-specific accuracy:** For more important or challenging classes (e.g., distinguishing specific words in a noisy environment), specific accuracy targets can be set for each. A higher accuracy might be required for identifying critical sounds in a safety alert project.
    - **Precision and recall (Simplified):** These metrics offer a more detailed understanding of your model's performance. "Precision" indicates how often the model was correct when it said something belonged to a certain class. "Recall" measures how often the model correctly identified something that *actually* belonged to a certain class. A balanced model typically performs well on both.
    - **Response time:** If real-time audio recognition is required (e.g., for voice commands), set a target for the maximum acceptable response time. This measures the time taken for the model to process an audio input and provide a classification.
- **Functionality and usability:** Define criteria related to your project's functionality and usability, especially if it's intended for a specific application or user group.
    - **Ease of use:** If your project includes a user interface, criteria for its ease of use and intuitiveness must be defined. Consider if users can easily interact with the model and understand its output.
    - **Integration:** For projects intended for integration with another system or application, define criteria for successful integration. Verify if it seamlessly connects and exchanges data with the other system.

Funded by the European Union

Funded by the European Union. However, the views expressed belong to the author(s) alone and do not necessarily reflect the views of the European Union or the Erasmus+ National Agency -INDIRE. Neither the European Union nor the granting administration can be held responsible for them. Project N°: 2024-1-IT02-KA220-SCH-000249373



    - **Accessibility:** If your project targets a diverse user group, establish criteria for its accessibility. Is it usable by individuals with hearing impairments or other special needs (e.g., through visual feedback)?
- **Educational impact (If applicable):** For projects designed for educational purposes, define criteria related to their impact on student learning.
    - **Learning outcomes:** Does the project assist students in achieving the intended learning outcomes? Can students demonstrate improved knowledge or skills after using the project, such as enhanced listening comprehension or pronunciation?
    - **Engagement:** Does the project engage students and motivate them to learn? Do students find the project interesting and enjoyable?
    - **Student feedback:** Collect feedback from students regarding their experience with the project. Do they find it helpful, informative, or enjoyable?
- **Technical requirements:** Define criteria related to any specific technical requirements for your project.
    - **Platform compatibility:** Does the project operate correctly on the intended platforms or devices?
    - **Resource usage:** Does the project utilize resources efficiently? Does it run smoothly without consuming excessive processing power or memory?
- **Ethical Considerations:** Incorporate ethical considerations into your success criteria.
    - **Bias mitigation:** Does the project demonstrate fairness and minimize bias in its predictions (e.g., for different accents or vocal tones)?
    - **Privacy protection:** Does the project protect user privacy and handle audio data responsibly?

Examples of success criteria for Audio projects:

- "The audio recognition model achieves an overall accuracy of 88% in classifying different animal sounds."
- "Students using the pronunciation feedback project demonstrate a 15% improvement in correctly pronouncing target vocabulary words."
- "The environmental sound recognition tool correctly identifies 90% of common household noises and provides appropriate visual alerts."

By defining clear, measurable, and relevant success criteria, you effectively guide the development of your Teachable Machine Audio Project and ensure it meets your intended goals.

Funded by the European Union

Funded by the European Union. However, the views expressed belong to the author(s) alone and do not necessarily reflect the views of the European Union or the Erasmus+ National Agency -INDIRE. Neither the European Union nor the granting administration can be held responsible for them. Project N°: 2024-1-IT02-KA220-SCH-000249373

4.2 Data collection and preparation: Building your dataset for Audio

Data forms the lifeblood of any Machine Learning model. The quality, quantity, and diversity of your audio data directly impact the performance and accuracy of your Teachable Machine project. Therefore, planning a robust data collection strategy is essential for building a successful model.

4.2.1 Gathering Audio data: Sources and methods

The quality and diversity of your audio dataset are paramount to the success of your Teachable Machine Audio Project. A well-constructed dataset enables your model to learn effectively and make accurate predictions. This section outlines various sources and methods for gathering audio data:

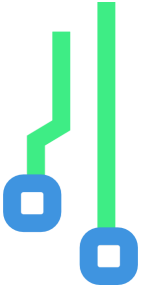
- **Microphone recording:** Teachable Machine provides a convenient feature allowing direct audio capture using your computer's microphone. This method proves particularly useful for collecting sounds that are easily reproducible or voice samples specific to your project.
    - **Advantages:**
        - Data collection is easy and quick for live input.
        - Direct control over sound characteristics (e.g., volume, clarity) is possible.
        - Real-time capture of specific sounds or voice patterns is supported.
    - **Considerations:**
        - Environmental noise can interfere with recordings; ensure a quiet recording environment.
        - Microphone quality can affect the clarity of the audio data.
        - The sounds or voices must be reproducible for consistent data collection.

💡**Teacher's tip:**

The "Golden Rule" for Audio background noise: Do not record your "Background Noise" class in total silence! Instead, record 20–30 seconds of the actual ambient noise of your classroom (such as distant whispers, chair scraping, keyboard clicks, or the hum of the air conditioner). This teaches the AI what specific ambient sounds it must ignore when listening for target voice commands or acoustic triggers.

Funded by the European Union

Funded by the European Union. However, the views expressed belong to the author(s) alone and do not necessarily reflect the views of the European Union or the Erasmus+ National Agency -INDIRE. Neither the European Union nor the granting administration can be held responsible for them. Project N°: 2024-1-IT02-KA220-SCH-000249373



- **Existing audio libraries and databases:** Numerous online audio libraries and databases offer vast collections of sounds and voice recordings suitable for your Teachable Machine projects. These resources are particularly helpful for accessing sounds not easily recordable in your environment.
    - **Examples of resources:**
        - Freesound: Offers a collaborative database of audio snippets, effects, and recordings.
        - Soundbible: Provides free sound clips for various uses.
        - Specialized Databases: Depending on your project, specialized databases (e.g., environmental sound databases, speech corpora) may be available.
    - **Advantages:**
        - Access to a wide variety of sounds and voice patterns is granted.
        - Time and effort are saved compared to recording all audio yourself.
        - Access to sounds or voices otherwise difficult to obtain is provided.
    - **Considerations:**
        - Be mindful of copyright restrictions and usage rights for commercial or public use.
        - Audio quality and consistency may vary across different sources.
        - Careful filtering or selection of audio ensures relevance to your project and ethical handling of voice data.
- **Personal audio collections:** If you possess a personal collection of audio recordings (e.g., voice notes, sound effects), some might be usable for your Teachable Machine project. This can be a good option for collecting unique or familiar sounds.
    - **Advantages:**
        - Easy access to an existing audio collection.
        - Recordings are likely relevant to your context.
        - A personal touch is added to your project.
    - **Considerations:**
        - Ensure you have the right to use the audio.
        - Audio quality and consistency may vary.
        - Careful selection ensures appropriateness for your project and protects privacy.
- **Audio augmentation:** This technique involves artificially increasing the size and diversity of your dataset by applying various transformations to existing audio samples. This can be a valuable method for improving your model's performance.

Funded by the European Union

Funded by the European Union. However, the views expressed belong to the author(s) alone and do not necessarily reflect the views of the European Union or the Erasmus+ National Agency -INDIRE. Neither the European Union nor the granting administration can be held responsible for them. Project N°: 2024-1-IT02-KA220-SCH-000249373

- **Examples of augmentation techniques:**
  - **Adding noise:** Introducing background noise (e.g., white noise, common environmental sounds) helps the model become more robust to real-world noisy conditions.
  - **Pitch shifting:** Adjusting the pitch of audio samples helps the model recognize sounds at different frequencies.
  - **Time stretching:** Changing the speed of audio samples without altering pitch helps the model recognize sounds at varying tempos.
  - **Volume adjustments:** Varying the volume of audio samples makes the model more resilient to different loudness levels.
- **Advantages:**
  - Increases the size and diversity of your dataset without collecting new audio.
  - Can improve your model's ability to generalize and handle audio variations.
  - Helps prevent overfitting (when the model learns the training data too well and performs poorly on new data).
- **Considerations:**
  - Use augmentation techniques judiciously; avoid transforming audio to the point where it no longer sounds realistic.
  - Consider your project's specific requirements and choose augmentation techniques relevant to variations your model is likely to encounter.
  - Monitor your model's performance on a validation set (data not used for training) to ensure augmentation improves generalization and does not hinder performance.

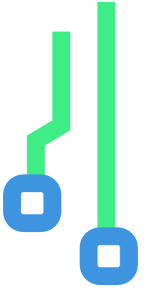
When gathering audio data, prioritizing quality, diversity, and relevance is crucial. Ensure your audio samples are clear, free from excessive background noise, and representative of the sounds or voice patterns your model must recognize.

4.2.2 Creating Audio Classes: Defining Categories for Your Model

In Teachable Machine, "classes" represent the distinct categories or labels your audio recognition model learns to identify. Clearly and accurately defining these classes is a crucial step in preparing your dataset and ensuring your model effectively distinguishes between different sounds or voice patterns. Here's a guide to creating audio classes:

Funded by the European Union

Funded by the European Union. However, the views expressed belong to the author(s) alone and do not necessarily reflect the views of the European Union or the Erasmus+ National Agency -INDIRE. Neither the European Union nor the granting administration can be held responsible for them. Project N°: 2024-1-IT02-KA220-SCH-000249373



- **Clearly Define Your Categories:** Before adding audio samples, take time to carefully define the categories your model will recognize. Each class must represent a specific sound, voice pattern, or classification relevant to your project goals. Ensure categories are well-defined, unambiguous, and mutually exclusive (to the extent possible). This means minimal overlap or confusion between categories. For example, if classifying animal sounds, classes might be "dog bark," "cat meow," "bird chirp," and "cow moo."
- **Determine the Number of Classes:** The number of classes needed depends on your project's complexity and the number of distinct sounds or voice patterns to recognize. Start with a manageable number, especially as a beginner. Additional classes can always be added later if needed. Consider the trade-off between the number of classes and the data required; more classes generally demand more data for effective model training.
- **Name Your Classes Appropriately:** Assign clear, descriptive names to your classes that accurately reflect the sounds or voice patterns they represent. This aids organization and ensures easy understanding of each class's purpose. Use consistent naming conventions, for example, specific sound descriptions (e.g., "doorbell ring" instead of just "ring") or clear vocal labels.
- **Create Classes in Teachable Machine:** Teachable Machine provides a user-friendly interface for creating and managing classes. An area for adding new classes, renaming existing ones, or deleting classes is available. Follow the on-screen instructions to create your classes and assign appropriate names.
- **Consider Ethical Implications for Voice Data:** When working with voice or speech data, always be particularly mindful of ethical considerations. Ensure you have proper consent for recording voices, especially from students. Prioritize privacy and avoid collecting any sensitive personal information through audio.
- **Review and Refine Your Classes:** After creating your initial set of classes, carefully review them to ensure appropriateness for your project goals. Consider whether adding, removing, or renaming classes is necessary. Often, refining classes becomes helpful after starting data collection, as a better understanding of data variations is gained.

By carefully defining and creating your audio classes, you establish a solid foundation for your Teachable Machine Audio Project, ensuring your model effectively learns to distinguish between the specified categories.

Funded by
the European Union

Funded by the European Union. However, the views expressed belong to the author(s) alone and do not necessarily reflect the views of the European Union or the Erasmus+ National Agency -INDIRE. Neither the European Union nor the granting administration can be held responsible for them. Project N°: 2024-1-IT02-KA220-SCH-000249373

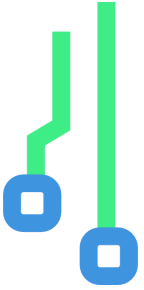
4.2.3 Audio augmentation: Enhancing your dataset

Audio augmentation is a powerful technique for artificially increasing the size and diversity of your audio dataset. This involves applying various transformations to existing audio samples to create new, slightly modified versions. This method can significantly improve your Teachable Machine Audio Project's robustness and generalization ability, helping it perform well on unseen data, especially in real-world environments with varying audio conditions. Here's a guide to audio augmentation:

- **Why use audio augmentation?**
  - **Increased dataset size:** Augmentation allows the generation of more training data from existing audio, effectively expanding your dataset without needing to collect new samples. This is particularly useful when original audio recordings are limited.
  - **Improved generalization:** By introducing variations in your training data, augmentation helps the model learn more robust features and become less sensitive to specific characteristics in the training audio. This enhances the model's ability to generalize to new, unseen audio that may differ slightly from the training data.
  - **Reduced overfitting:** Overfitting occurs when a model learns the training data too well, including its noise and idiosyncrasies, leading to poor performance on new data. Augmentation helps prevent overfitting by making the model less reliant on specific training examples and encouraging it to learn more generalizable features for diverse audio inputs.
- **Common augmentation techniques:**
  - **Adding noise:** Introducing background noise (e.g., white noise, common classroom sounds, street noise) helps the model become more robust to real-world noisy conditions. This simulates more realistic environments.
  - **Pitch shifting:** Adjusting the pitch of audio samples helps the model recognize sounds or voices at different frequencies, which can occur naturally (e.g., different speakers, instrument variations).
  - **Time stretching:** Changing the speed of audio samples without altering pitch helps the model recognize sounds at varying tempos. This is useful for speech recognition or musical rhythm variations.
  - **Volume adjustments:** Varying the volume of audio samples makes the model more resilient to different loudness levels. This prepares the model for recordings with varying recording volumes or distances from the sound source.

Funded by the European Union

Funded by the European Union. However, the views expressed belong to the author(s) alone and do not necessarily reflect the views of the European Union or the Erasmus+ National Agency -INDIRE. Neither the European Union nor the granting administration can be held responsible for them. Project N°: 2024-1-IT02-KA220-SCH-000249373



- **Silence insertion:** Adding short periods of silence at the beginning or end of audio clips can make the model more robust to varying audio lengths and pauses.

- **Applying audio augmentation:**
  - **Teachable Machine's built-in features:** While Teachable Machine handles some aspects of sound processing internally, its direct augmentation features are more limited compared to external tools. Focus on providing diverse original samples.
  - **External tools and libraries (For advanced exploration):** For applying specific augmentation techniques like adding noise or pitch shifting, external audio editing software (e.g., Audacity) or programming libraries (like Python's Librosa or Audiomentations) are generally used. For primary teachers, focusing on providing varied and clean *original* samples is often the most effective approach for simpler projects; these external tools are for deeper exploration and more complex challenges.
- **Augmentation best practices:**
  - Apply augmentation techniques judiciously. Avoid over-augmenting data to the point where transformed audio no longer sounds realistic or representative of the originals.
  - Consider your project's specific requirements and choose augmentation techniques relevant to variations your model is likely to encounter in real-world audio.
  - Monitor your model's performance on a validation set (data not used for training) to ensure augmentation improves generalization and does not hinder performance.

By effectively utilizing audio augmentation, you enhance the robustness, accuracy, and generalization of your Teachable Machine Audio Projects, leading to more reliable and effective sound recognition models, especially in varied acoustic environments.

4.2.4 Preparing your data for Teachable Machine

Once your audio data is gathered and any desired augmentation techniques applied, the next step involves preparing it for use in Teachable Machine. Proper data preparation ensures your audio samples are in the correct format, organized effectively, and ready for training your ML model. Here's a guide to preparing your data:

- **Audio file formats:** Teachable Machine typically supports common audio file formats. WAV (.wav) is often preferred for its uncompressed quality, but MP3 (.mp3) or other

Funded by the European Union

Funded by the European Union. However, the views expressed belong to the author(s) alone and do not necessarily reflect the views of the European Union or the Erasmus+ National Agency -INDIRE. Neither the European Union nor the granting administration can be held responsible for them. Project N°: 2024-1-IT02-KA220-SCH-000249373

common formats may also be supported. Ensure your audio samples are saved in a compatible format. If other formats are used, conversion via audio editing software or online tools may be necessary.

- **Audio length and segmentation:** Consider the length of your audio samples. For event detection (e.g., clapping, doorbell), short, distinct clips are ideal. For speech, longer clips containing the phrase are needed. If working with continuous audio, segmentation into smaller, manageable clips corresponding to each class is necessary. Maintaining consistency in audio clip length across your dataset can be beneficial for model training.

💡**Teacher's tip:**

Recording tip for students: Teachable Machine extracts samples in 1-second or 2-second windows depending on your settings . To achieve strong accuracy, record at least 20 to 30 distinct samples per class. If training the model to recognize a specific word (such as "Hello"), have students repeat the word at different pitches, speeds, and volumes within those clips.

- **Data organization:** Organize your audio files into folders corresponding to the classes defined in Teachable Machine. Create a separate folder for each class and place relevant audio samples within it. This folder structure facilitates easy data upload to Teachable Machine, as entire folders can typically be uploaded at once. Use clear and consistent naming conventions for your audio files to ensure logical organization.
- **Data cleaning:** Before uploading, take time to review and clean your audio dataset. Remove any irrelevant, inappropriate, corrupted, or excessively noisy audio files. If needed, edit audio to improve quality or consistency (e.g., removing long silences, normalizing volume). Ensure audio clarity is paramount.
- **Data splitting (Optional but recommended):** For more advanced Machine Learning practices, splitting your dataset into three subsets is recommended:
    - **Training set:** The largest subset, used to train the ML model.
    - **Validation set:** Used to evaluate model performance during training and tune hyperparameters.
    - **Test set:** Used to evaluate the final model's performance after training is complete. Teachable Machine does not require explicit splitting for basic use, but it is a good

Funded by the European Union

Funded by the European Union. However, the views expressed belong to the author(s) alone and do not necessarily reflect the views of the European Union or the Erasmus+ National Agency -INDIRE. Neither the European Union nor the granting administration can be held responsible for them. Project N°: 2024-1-IT02-KA220-SCH-000249373

practice for rigorous model evaluation. A similar effect is achieved by reserving a portion of your data and not using it during the initial training phase. If data splitting is chosen, ensure similar class distribution across all subsets.

- **Uploading data to Teachable Machine:** Once your data is prepared, it is ready for upload to Teachable Machine. The platform provides user-friendly tools for uploading audio, typically allowing you to:
    - Record audio directly using your microphone.
    - Upload audio files from your computer. Follow the on-screen instructions to upload your data and associate it with the correct classes.

By carefully preparing your data, you ensure it is in optimal condition for training your Teachable Machine Audio Project, leading to better model performance and more reliable results.

💡**Teacher's tip:**

Classroom management strategy: Preventing "sound bleeding": To avoid acoustic interference (where one group's voice gets recorded into another group's model), organize the room using one of two strategies:

- **Recording stations:** Set up designated recording stations in different corners of the classroom or in the hallway.
- **Staggered workflow:** Divide the class so that half the students work on class definitions, labels, and documentation while the other half records audio samples in rotation.

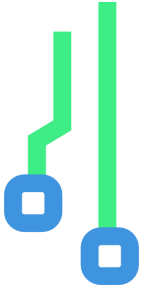
4.3 Model training and evaluation: Bringing your Audio AI to life

4.3.1 Training your Audio model: Step-by-step

Once your audio dataset is prepared, the next step involves training your Machine Learning model in Teachable Machine. This training process entails feeding your audio data to the model, allowing it to learn and recognize the patterns and features that distinguish between the different sound classes you have defined. Teachable Machine simplifies this process, making it accessible even to those without coding experience. Here's a step-by-step guide to training your audio model:

Funded by the European Union

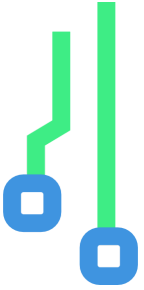
Funded by the European Union. However, the views expressed belong to the author(s) alone and do not necessarily reflect the views of the European Union or the Erasmus+ National Agency -INDIRE. Neither the European Union nor the granting administration can be held responsible for them. Project N°: 2024-1-IT02-KA220-SCH-000249373



- **Access your project:** Open Teachable Machine and access the Audio Project on which you have been working. Ensure that your audio data is uploaded and organized into the correct classes.
- **Review your data:** Before starting the training process, take a moment to review your data. Confirm its accuracy and ensure each class contains a sufficient number of representative audio samples. You can typically listen to the audio samples in each class directly within the Teachable Machine interface. Pay attention to background noise or inconsistencies.
- **Initiate training:** Teachable Machine provides a clear button or control to start the training process. This is a prominent button, typically labeled "Train Model." Click this button to begin the training.
- **Training process:** Once training is initiated, Teachable Machine begins processing your audio data. The platform utilizes Machine Learning algorithms to analyze the audio and identify key features that distinguish between classes. During training, the model adjusts its internal parameters to optimize its ability to classify sounds correctly. Teachable Machine provides visual feedback on the training progress. This includes progress bars, messages, or animations indicating that training is underway. The duration of the training process depends on your dataset's size and complexity, as well as your computer's processing power or the platform's servers.
- **No coding required:** A key advantage of Teachable Machine is its handling of complex model training computations in the background. You do not need to write any code or possess specialized knowledge of Machine Learning algorithms to train your model.
- **Advanced training settings (Optional for deeper exploration):** While designed for simplicity, Teachable Machine offers "Advanced Settings" that allow users to fine-tune the training process. These settings can influence how the model learns and its final performance. The availability and specific nature of these settings might vary slightly with Teachable Machine platform updates.
    - **Epochs:** An epoch represents one complete pass through the entire training dataset during the training process. Increasing epochs generally allows more thorough learning, but also raises the risk of overfitting (where the model performs well on training data but poorly on new data). Teachable Machine allows epoch adjustment, providing control over training duration.
    - **Batch size:** This refers to the number of data samples (audio clips, in this case) the model processes at a time during each parameter update. Adjusting batch size

Funded by the European Union

Funded by the European Union. However, the views expressed belong to the author(s) alone and do not necessarily reflect the views of the European Union or the Erasmus+ National Agency -INDIRE. Neither the European Union nor the granting administration can be held responsible for them. Project N°: 2024-1-IT02-KA220-SCH-000249373



affects training speed and learning dynamics. Teachable Machine offers options for different batch sizes.

- **Learning rate:** A crucial parameter, the learning rate controls the step size the model takes to update its parameters based on calculated error (loss). A learning rate that is too high causes divergence and learning failure, while one that is too low significantly slows the training process. While Teachable Machine simplifies many aspects, advanced machine learning workflows involve this rate. If available as an option, proceed with caution.
- **Other hyperparameters:** Machine learning models possess parameters called hyperparameters that control the learning process. Teachable Machine exposes some of these for adjustment. Tuning these often requires experimentation and an understanding of machine learning principles.
- **Using advanced settings:** If choosing to use advanced settings, a systematic approach is generally recommended. Change one setting at a time, observe its impact on model performance, and meticulously track experiments and results. Effective use often demands a deeper understanding of machine learning concepts. For those new to machine learning, starting with default settings and gradually exploring advanced options as experience is gained is advisable.

- **Training tips:**
  - **Start with sufficient data:** Ensure adequate data in each class before training. A balanced dataset with a reasonable number of audio samples per class generally yields better results.
  - **Monitor progress (If available):** If Teachable Machine provides feedback on training progress, monitor it to understand how the model learns.
  - **Iterative training:** Training the model multiple times may be necessary, especially if initial results are unsatisfactory. Adjust your dataset, add more data, or modify classes, then retrain the model.
- **Completion of training:** Once the training process concludes, Teachable Machine notifies you. Your audio recognition model is now trained and ready for evaluation and use.

Teachable Machine simplifies the training process, making it accessible to a wide range of users. By following these steps and ensuring a well-prepared dataset, you effectively train your audio model and begin exploring its capabilities.

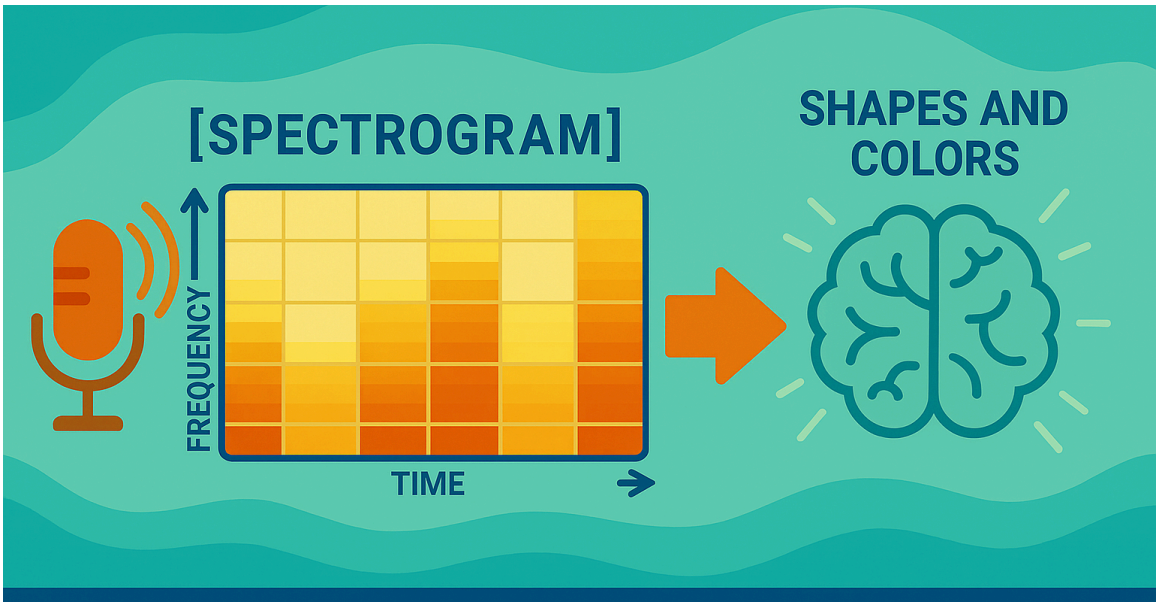
Funded by the European Union

Funded by the European Union. However, the views expressed belong to the author(s) alone and do not necessarily reflect the views of the European Union or the Erasmus+ National Agency -INDIRE. Neither the European Union nor the granting administration can be held responsible for them. Project N°: 2024-1-IT02-KA220-SCH-000249373

M{AI}L

How audio recognition works (Simplified):

Machine Learning for audio works by transforming sound into a visual map of frequencies called a spectrogram. The system detects shapes and colors on this map to find patterns unique to each sound.

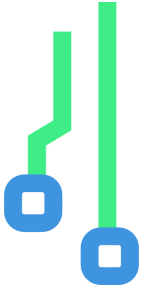


🧠 Simplified process				
1. Record samples	2. Convert to spectrograms	3. Train model	4. Test new sounds	5. Improve with feedback

Teachers can show how changing volume, background noise, or microphone distance affects results. This helps students understand why controlled, varied data is important.

Funded by the European Union

Funded by the European Union. However, the views expressed belong to the author(s) alone and do not necessarily reflect the views of the European Union or the Erasmus+ National Agency -INDIRE. Neither the European Union nor the granting administration can be held responsible for them. Project N°: 2024-1-IT02-KA220-SCH-000249373



📝**Patience note :**

Browser tab activity: Processing spectrographic audio data requires more computational power than standard image arrays. Ensure students keep the Teachable Machine browser tab active and visible on their screen during training. If they minimize the window or switch to another browser tab, the training process will slow down or pause completely[.

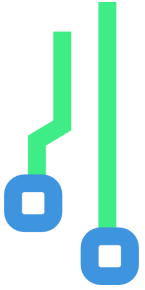
4.3.2 Evaluating model performance: Understanding accuracy and metrics

After training your audio model in Teachable Machine, evaluating its performance is crucial to determine how well it works and whether it meets your project's success criteria. Evaluation involves testing the model with audio data it has not heard during training and analyzing its predictions. Here's a guide to evaluating model performance for audio projects:

- **Teachable Machine's preview:** A built-in preview feature in Teachable Machine allows for quick testing of your trained model. You can use your microphone to provide new audio input or upload existing audio files, then observe how the model classifies them. This preview offers an intuitive way to gauge your model's performance quickly. Observe if the model correctly identifies sounds or voice patterns in the audio provided. Pay attention to any misclassifications or instances where the model appears uncertain.
- **Understanding accuracy:** Accuracy stands as a common metric for evaluating classification models. It represents the overall proportion of correct predictions made by the model. For example, if you provide the model with 100 test audio clips and it correctly classifies 90, the accuracy is 90%. While accuracy is a useful metric, its limitations, especially with imbalanced datasets (where some classes have significantly more data than others), are important to consider.
- **Confusion matrix:** A confusion matrix provides a more detailed breakdown of your model's performance. This table shows the number of correct and incorrect predictions for each class. The rows typically represent the actual classes, while the columns represent the predicted classes. Analyzing the confusion matrix helps identify which classes the model struggles to distinguish and where it makes the most errors.
- **Precision and recall (Simplified):** Other important metrics, precision and recall, offer a nuanced understanding of your model's performance, particularly with imbalanced datasets.

Funded by
the European Union

Funded by the European Union. However, the views expressed belong to the author(s) alone and do not necessarily reflect the views of the European Union or the Erasmus+ National Agency -INDIRE. Neither the European Union nor the granting administration can be held responsible for them. Project N°: 2024-1-IT02-KA220-SCH-000249373



    - **Precision:** Measures the proportion of positive identifications that were actually correct. It answers: "Of all the times the model said it was a certain class, how often was it right?"
    - **Recall:** Measures the proportion of actual positives that were correctly identified by the model. It answers: "Of all the times it *actually* was a certain class, how often did the model say so?" A high precision score indicates the model excels at avoiding false positives, while a high recall score signifies it is good at identifying all instances of a particular class.
- **F1-score (Simplified):** The F1-score combines precision and recall into a single value. It provides a balanced measure of a model's performance, especially when an imbalance exists between classes. Generally, a higher F1-score indicates better performance.
- **Evaluation best practices:**
    - **Use a separate test set:** For an unbiased evaluation, testing your model on data it has not encountered during training is crucial. This is known as a test set.
    - **Evaluate on representative data:** Ensure your test data accurately represents the real-world audio your model will encounter.
    - **Consider your project goals:** The most important metrics for evaluating your model depend on your project's specific goals. If avoiding false positives is critical (e.g., in a safety alert system), prioritize precision. If identifying all instances of a class is crucial (e.g., in a medical diagnosis system), prioritize recall.
    - **Iterative Evaluation:** Evaluation is an iterative process. You may need to evaluate your model multiple times, adjust your dataset or training process, and then re-evaluate to see if changes have improved performance.

By carefully evaluating your model's performance using appropriate metrics and best practices, you gain a clear understanding of its strengths and weaknesses and make informed decisions on how to improve it.

4.3.3 Troubleshooting and improving your model

Encountering challenges and areas for improvement is common when training and evaluating your Teachable Machine Audio Project. Your model might not perform as expected initially, or you might notice specific weaknesses in its predictions. Troubleshooting and iteratively improving your model are essential parts of the Machine Learning process. Here's a guide to help you:

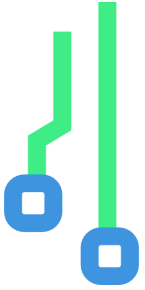
Funded by the European Union

Funded by the European Union. However, the views expressed belong to the author(s) alone and do not necessarily reflect the views of the European Union or the Erasmus+ National Agency -INDIRE. Neither the European Union nor the granting administration can be held responsible for them. Project N°: 2024-1-IT02-KA220-SCH-000249373

- **Identify common problems:**
  - **Low accuracy:** The model makes a large number of incorrect predictions.
  - **Overfitting:** The model performs well on the training data but poorly on new, unseen data. This indicates that the model has learned the training data too well, including its noise and idiosyncrasies.
  - **Confusion between classes:** The model struggles to distinguish between certain classes, often misclassifying audio from one class as another. This is common when sounds are very similar.
  - **Bias:** The model performs significantly better on some groups or categories (e.g., certain accents, specific instruments) than others, indicating potential bias in the data or model.
- **Strategies for troubleshooting and improvement:**
  - **Increase data quantity:** If your model exhibits low accuracy, increasing the amount of training data is a common solution. Collect more audio samples for each class, ensuring a balanced dataset. A larger dataset provides the model with more information to learn from, improving its generalization ability.
  - **Improve data quality and diversity:** Review your existing data to identify any low-quality or unrepresentative audio samples. Remove recordings with excessive background noise, distortions, or irrelevance. Increase your dataset's diversity by capturing audio from different sources, in various acoustic environments, and with different recording devices. Apply audio augmentation techniques to artificially increase data diversity.
  - **Refine your classes:** If your model confuses certain classes, review your class definitions to ensure clarity and distinctiveness. If necessary, merge similar classes or create more specific sub-classes to reduce ambiguity. Ensure audio samples within each class are representative and do not significantly overlap with other classes.
  - **Address overfitting:** When your model is overfitting, consider these approaches:
    - **Data augmentation:** As mentioned previously, augmentation helps prevent overfitting.
    - **Simplify the model (If applicable):** While Teachable Machine abstracts much of the model architecture, in more advanced ML, simplifying the model sometimes helps with overfitting.

Funded by the European Union

Funded by the European Union. However, the views expressed belong to the author(s) alone and do not necessarily reflect the views of the European Union or the Erasmus+ National Agency -INDIRE. Neither the European Union nor the granting administration can be held responsible for them. Project N°: 2024-1-IT02-KA220-SCH-000249373



        - **Early stopping (If available):** Some training systems incorporate "early stopping," where training halts when performance on a validation set begins to degrade.
    - **Check for bias:** Carefully analyze your dataset for potential sources of bias. Ensure your data represents the variety of sounds or voices your model is intended to process. If bias is identified (e.g., poor performance on certain accents), collect more diverse data to balance your dataset and mitigate the bias. Evaluate your model's performance across different groups and categories to identify and address any disparities.
    - **Iterative training and evaluation:** Troubleshooting and improvement are iterative processes. Make small changes to your dataset, training process, or class definitions, then retrain and re-evaluate your model. Meticulously track the changes made and their impact on performance. Use evaluation metrics (accuracy, precision, recall, confusion matrix) to guide your improvements.
    - **Seek help and resources:** If you struggle to improve your model's performance, do not hesitate to seek help and resources. Online forums, tutorials, and communities offer valuable insights and guidance. Teachable Machine's documentation and support resources also provide helpful tips and troubleshooting advice.

By systematically troubleshooting and iteratively improving your model, you overcome challenges, enhance its performance, and achieve desired results in your Teachable Machine Audio Projects.

4.4 Applications in the classroom: Audio AI in action

4.4.1 Interactive learning activities with audio recognition

Audio recognition technology, powered by Teachable Machine, serves as a valuable tool for creating engaging and interactive learning activities in the classroom. Incorporating audio-based AI into your lessons provides students with hands-on experiences, enhances their understanding of concepts related to sound, and fosters a more dynamic learning environment. Here are some examples of interactive learning activities with audio recognition:

- **Sound scavenger hunts:** Design a scavenger hunt activity where students utilize a Teachable Machine model to identify specific sounds within their classroom, school, or

Funded by the European Union

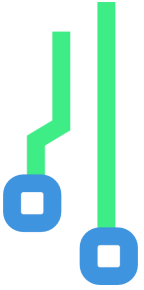
Funded by the European Union. However, the views expressed belong to the author(s) alone and do not necessarily reflect the views of the European Union or the Erasmus+ National Agency -INDIRE. Neither the European Union nor the granting administration can be held responsible for them. Project N°: 2024-1-IT02-KA220-SCH-000249373

outdoor environment. Students can use a tablet or smartphone equipped with the Teachable Machine model to "listen" to their surroundings, searching for designated sounds. This activity promotes active listening skills, encourages exploration of acoustic environments, and makes learning more engaging. For instance, younger students might search for sounds of different animals, vehicles, or musical instruments, while older students could identify distinct sounds from different materials or processes in a science lab.

- **Interactive pronunciation practice:** Develop an interactive pronunciation tool where students practice speaking words or phrases in a target language. A Teachable Machine model can be trained to recognize correct pronunciation, providing immediate feedback. This allows students to refine their speaking skills independently, making language learning more dynamic and personalized. For example, students record themselves saying a word, and the model indicates if the pronunciation is correct or suggests areas for improvement.
- **Sound matching games:** Creating sound matching games is an effective way to reinforce auditory discrimination and classification skills. These games involve students matching a heard sound to its corresponding image, word, or category using the Teachable Machine model. This is particularly useful in music (matching instrument sounds to images of instruments) or science (matching animal sounds to animal pictures). The interactive nature provides immediate feedback, making learning enjoyable.
- **Audio-driven storytelling and creative writing:** Audio recognition can spark creativity and storytelling activities. Students can utilize a Teachable Machine model to trigger different sound effects or musical cues based on spoken words, environmental sounds, or even their own vocalizations, allowing for interactive soundscapes or enhancing narrative experiences. This activity enhances students' imagination, language skills, and narrative abilities, fostering multimodal expression. For example, students could create a story where specific words trigger associated sound effects, immersing listeners in the narrative.
- **Environmental sound monitoring:** Students can build projects that monitor and classify environmental sounds in the classroom or specific locations. This can involve identifying sounds like "door opening," "bell ringing," or "quiet reading time." This activity teaches students about soundscapes, data collection, and how AI can be used for monitoring and organization.
- **Music composition and exploration:** Engage students in basic music composition or exploration activities. A Teachable Machine model can be trained to recognize simple

Funded by the European Union

Funded by the European Union. However, the views expressed belong to the author(s) alone and do not necessarily reflect the views of the European Union or the Erasmus+ National Agency -INDIRE. Neither the European Union nor the granting administration can be held responsible for them. Project N°: 2024-1-IT02-KA220-SCH-000249373



vocalizations or instrument sounds and then trigger different musical notes or melodies. This allows students to experiment with sound and understand basic principles of music theory through interaction.

These interactive learning activities demonstrate the potential of audio recognition to transform the classroom experience, making it more engaging, interactive, and effective.

4.4.2 Integrating audio AI into subject-specific lessons

Teachable Machine's audio recognition capabilities integrate seamlessly into a wide range of subject-specific lessons, enriching the curriculum and providing students with unique learning experiences. By tailoring audio AI projects to specific subjects, educators enhance student engagement, promote deeper understanding, and foster interdisciplinary learning. Here are some examples of how to integrate audio AI into different primary school subjects:

- **Music and Performing Arts:**
  - **Instrument identification:** Projects can be developed that classify different musical instruments from recordings. Students analyze musical pieces, using audio recognition to identify instruments being played, their roles, or orchestral arrangements. This enhances music appreciation and develops auditory skills.
  - **Musical genre classification:** Create projects that classify musical pieces based on their genre, style, or instrumentation. Students analyze recordings to identify musical characteristics and categorize them. Audio recognition supports exploring music history, analyzing musical trends, or creating interactive music quizzes.
  - **Melody and rhythm analysis:** Projects can analyze and compare different melodies or rhythmic patterns. Students record or analyze musical phrases, using audio recognition to identify melodic contours, rhythmic variations, or musical structures. This aids music composition, improvisation, or performance.
- **Language Arts and Communication:**
  - **Pronunciation practice:** Highly effective projects can be developed to assist students with pronunciation in foreign languages or even complex words in their native tongue. Students record themselves saying words or phrases, and the Teachable Machine model provides immediate feedback on whether their pronunciation matches a correct example. This fosters independent practice and improves speaking fluency.

Funded by the European Union

Funded by the European Union. However, the views expressed belong to the author(s) alone and do not necessarily reflect the views of the European Union or the Erasmus+ National Agency -INDIRE. Neither the European Union nor the granting administration can be held responsible for them. Project N°: 2024-1-IT02-KA220-SCH-000249373

- **Speech pattern analysis:** Projects can be designed to analyze patterns in speech, such as tone, rhythm, or intonation. This is valuable for understanding dramatic reading, public speaking, or different forms of verbal communication.
- **Oral history projects:** Create projects involving recording and analyzing oral histories. Students use audio recognition to transcribe interviews, identify key themes, or analyze individual or community narratives. This preserves cultural heritage, promotes intergenerational learning, or supports community-based research.

- **Environmental and life sciences:**
  - **Animal vocalizations:** Projects can be created that classify different animal vocalizations (e.g., bird calls, frog croaks, insect sounds) in various ecosystems. Students collect recordings of animal sounds in nature or utilize existing audio from documentaries or online databases. Audio recognition aids in identifying different species, analyzing animal communication, or studying biodiversity.
  - **Environmental noise monitoring:** Projects can be developed that monitor and analyze environmental noise pollution. Students record sounds in their community and use audio recognition to identify sources of noise pollution, measure noise levels, or assess the impact of noise on the environment. This raises awareness about environmental issues and promotes solutions for noise reduction.
- **Science of sound (Physics):**
  - **Sound wave analysis:** Projects can classify different types of sound waves based on frequency or amplitude. Students record sounds from various sources (e.g., tuning forks, musical instruments) and analyze their waveforms. Audio recognition helps visualize sound waves, explore concepts like resonance, or study the properties of sound.

These examples illustrate audio AI's versatility in education, demonstrating its adaptability to enhance learning across various subjects. Integrating Teachable Machine Audio Projects into subject-specific lessons allows educators to create engaging, interactive, and effective learning experiences for their students.

Summary table: Cross-curricular Audio projects at a glance:

Subject	Classroom project idea	Learning goal
Music and Performing Arts	Distinguish between violin,	Develop auditory

Funded by the European Union

Funded by the European Union. However, the views expressed belong to the author(s) alone and do not necessarily reflect the views of the European Union or the Erasmus+ National Agency -INDIRE. Neither the European Union nor the granting administration can be held responsible for them. Project N°: 2024-1-IT02-KA220-SCH-000249373

	flute, piano, and percussion sounds.	discrimination and instrument timbre recognition.
Language Arts and Communication	Train a model to recognize correct pronunciation vs. common phonetic errors.	Provide real-time automated feedback on phonetics and accents.
Environmental and life sciences	Classify local bird calls or monitor environmental noise levels.	Study bioacoustics, habitats, and noise pollution in the community.
Science of sound (Physics)	Record sound waves from striking wood vs. metal or different tuning forks	Analyze sound wave frequency, pitch, and material density.

4.4.3 Assessment strategies using audio-based AI projects

Audio-based AI projects, created with Teachable Machine, serve as valuable tools for various assessment strategies to evaluate student learning, provide feedback, and track progress, particularly in auditory skills and spoken communication. These projects offer unique opportunities for authentic assessment, allowing students to demonstrate understanding and skills in practical and engaging ways. Here are some examples of assessment strategies using audio-based AI projects:

- **Project-Based Assessment:** Assigning audio-based AI projects as a major assessment task requires students to design, develop, and evaluate their own sound or voice recognition models. Assess students' understanding of concepts and skills involved, such as data collection (recording), model training, evaluation, and application. Evaluate the quality of their projects, including model accuracy, functionality, and creativity. Provide opportunities for students to present their projects, explaining design choices and findings. Project-based assessment allows for a holistic evaluation of student learning and provides them with a sense of ownership over their work.
- **Performance-Based Assessment (Pronunciation/Auditory Skills):** Utilizing audio-based AI projects assesses students' ability to apply knowledge and skills in practical situations related to sound. Present students with scenarios or challenges requiring them to use their models for specific auditory tasks. Evaluate their performance

Funded by the European Union

Funded by the European Union. However, the views expressed belong to the author(s) alone and do not necessarily reflect the views of the European Union or the Erasmus+ National Agency -INDIRE. Neither the European Union nor the granting administration can be held responsible for them. Project N°: 2024-1-IT02-KA220-SCH-000249373

based on model prediction accuracy and effectiveness, as well as their ability to interpret and utilize results. For example, students could use a model to self-assess their pronunciation of complex words, or demonstrate their ability to classify environmental sounds.

- **Formative Assessment:** Audio-based AI projects can be integrated into formative assessment activities to monitor student learning and provide ongoing feedback. Use Teachable Machine models to create interactive quizzes, games, or activities that allow students to check their understanding of sound-related concepts or practice specific auditory skills. Provide students with immediate feedback on their responses, identifying areas needing additional support. Formative assessment with audio AI helps students track progress and pinpoint areas for improvement.
- **Self-Assessment and Peer Assessment:** Encourage students to use audio-based AI projects for self-assessment and peer assessment. This promotes metacognition, critical thinking, and collaboration skills. Students use their models to evaluate their own understanding of sounds or vocal patterns or provide feedback to classmates on their audio projects. Provide students with clear criteria and guidelines for self-assessment and peer assessment.
- **Portfolio Assessment:** Include audio-based AI projects in student portfolios to showcase their learning and achievements over time. Portfolios offer a comprehensive view of student growth and development, highlighting strengths, skills, and progress in auditory and AI-related areas. Students select their best projects for inclusion and reflect on their learning experiences.

Examples of assessment tasks for Audio Projects:

- "Design an audio recognition model that classifies different musical instruments and use it to identify instruments in a short musical piece."
- "Develop an audio-based quiz testing students' knowledge of animal sounds and their habitats."
- "Create a performance-based assessment where students use an audio recognition model to demonstrate correct pronunciation of ten new Spanish vocabulary words."
- "Use a Teachable Machine model to create an interactive activity helping students distinguish between different forms of vocal expression (e.g., happy, sad, questioning tone)."

Funded by the European Union

Funded by the European Union. However, the views expressed belong to the author(s) alone and do not necessarily reflect the views of the European Union or the Erasmus+ National Agency -INDIRE. Neither the European Union nor the granting administration can be held responsible for them. Project N°: 2024-1-IT02-KA220-SCH-000249373

By incorporating audio-based AI projects into a variety of assessment strategies, educators create authentic, engaging, and effective ways to evaluate student learning and promote deeper understanding in auditory-related subjects.

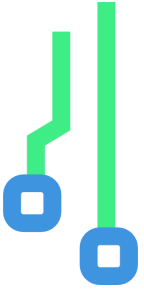
Funded by the European Union. However, the views expressed belong to the author(s) alone and do not necessarily reflect the views of the European Union or the Erasmus+ National Agency -INDIRE. Neither the European Union nor the granting administration can be held responsible for them. Project N°: 2024-1-IT02-KA220-SCH-000249373

M{AI}L

Module 5: Creating Pose Projects

Funded by the European Union. However, the views expressed belong to the author(s) alone and do not necessarily reflect the views of the European Union or the Erasmus+ National Agency -INDIRE. Neither the European Union nor the granting administration can be held responsible for them. Project N°: 2024-1-IT02-KA220-SCH-000249373

Funded by
the European Union



This module introduces Pose Projects in Teachable Machine. It is important to note that working with pose recognition can be more nuanced than image or audio projects. Consider this module an advanced option, best explored once you have gained confidence and experience with Image and Audio Projects. Pose Projects enable the creation of Machine Learning models that recognize and classify different body postures and movements.

5.1 Project planning: Defining your Pose-based AI

Careful planning remains essential for any Teachable Machine project, and Pose Projects are no exception. Defining your project's scope, identifying suitable applications, and establishing clear success criteria set the stage for effective development.

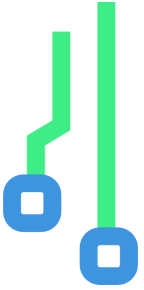
5.1.1 Identifying classroom applications for pose recognition

Pose recognition, powered by Machine Learning, offers unique interactive possibilities for enhancing physical and observational learning in the classroom. This technology creates opportunities for movement-based activities, facilitates the automation of gesture-controlled interfaces, and helps students understand body language or physical expressions. Here are some examples of classroom applications for pose recognition:

- **Physical education and movement analysis:** Pose recognition proves invaluable for building tools that help students identify and classify different physical exercises, dance moves, or yoga poses. Students, for instance, could train a model to recognize if they are performing a jumping jack correctly or holding a specific dance posture. This application offers immediate feedback, supporting proper form and technique.
- **Interactive learning games:** Integrating pose recognition into interactive games can make learning highly engaging and physically active. Teachers, for example, might create a game where students strike specific poses to answer questions or navigate a digital environment. This adds a kinetic dimension to learning, catering to kinesthetic learners.
- **Storytelling and dramatic play:** Pose recognition can enhance creative arts and storytelling by allowing students to trigger events or actions in a digital narrative through their body movements. Students could use a Teachable Machine model to advance a story as they act out different character poses or gestures. This fosters imagination, physical expression, and narrative abilities.
- **Assistive technologies and inclusive movement:** Tools designed to aid students with physical limitations or special needs can be developed using pose recognition. A project,

Funded by the European Union

Funded by the European Union. However, the views expressed belong to the author(s) alone and do not necessarily reflect the views of the European Union or the Erasmus+ National Agency -INDIRE. Neither the European Union nor the granting administration can be held responsible for them. Project N°: 2024-1-IT02-KA220-SCH-000249373



for example, might help a student practice specific therapeutic exercises by providing feedback on their posture, or assist in communicating through recognized gestures. This application promotes inclusivity and provides personalized support for physical activities.

- **Observation skills in science or social studies:** Students can build projects that observe and classify specific body language or social interactions (e.g., identifying poses indicating happiness, sadness, or confusion from a controlled set of examples). This introduces basic concepts of non-verbal communication analysis.

These examples represent just a few of the many classroom applications for pose recognition. The possibilities are vast, limited only by the creativity and ingenuity of educators and students, and careful consideration of ethical boundaries.

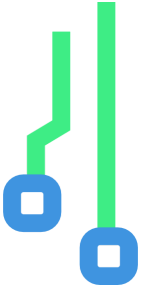
5.1.2 Choosing appropriate poses or movements for classification

Selecting the right poses or movements for your Pose Project is crucial for ensuring its success and educational value. Your choices directly influence the project's complexity, the feasibility of data collection, and its relevance to your learning objectives. Here are some key considerations for choosing appropriate poses or movements for classification in Teachable Machine:

- **Simplicity and distinguishability:** Start with poses or movements that are clearly distinct and easy to differentiate. Avoid categories that are too similar or involve subtle nuances, as these prove difficult for the model to learn accurately. For instance, rather than attempting to distinguish between slightly different hand gestures (which can be challenging), begin with something simpler, such as classifying broad movements (e.g., "standing," "sitting," "raising hand"). As students gain experience, they can gradually advance to more complex classification tasks.
- **Relevance to learning objectives:** Choose poses or movements that align directly with your specific learning objectives and curriculum goals. Select categories that will help students acquire new information, develop specific skills (e.g., motor skills, observational skills), or explore relevant topics. For example, in a physical education lesson, students could create a project classifying different warm-up exercises. Ensure the project supports and enhances the overall learning experience.
- **Feasibility of data collection:** Consider the ease and practicality of collecting sufficient data for your chosen poses or movements. Select categories for which a diverse and representative dataset can be readily obtained using a webcam. The poses must be consistently reproducible and easily visible to the camera. Avoid categories that require

Funded by the European Union

Funded by the European Union. However, the views expressed belong to the author(s) alone and do not necessarily reflect the views of the European Union or the Erasmus+ National Agency -INDIRE. Neither the European Union nor the granting administration can be held responsible for them. Project N°: 2024-1-IT02-KA220-SCH-000249373



complex setups, specific equipment beyond a webcam, or poses that are difficult to hold consistently.

- **Clarity of categories:** Define clear and unambiguous categories for your project. Ensure minimal overlap or ambiguity exists between these categories. Each category must represent a distinct and well-defined pose or movement. Avoid categories that are too broad or easily confused with one another. For example, instead of a single "dance" category, opt for distinct moves like "ballet plié" and "jazz square."
- **Student engagement and interest:** Choose poses or movements likely to engage and interest your students. Select categories relevant to their physical activities, games, or interests. Student interest in a project often translates to higher motivation for participation and learning. Consider involving students in the selection process by brainstorming ideas together and allowing them to choose appealing categories.
- **Ethical considerations and privacy:** Always be highly mindful of any ethical considerations related to collecting and using pose data, especially when working with students. Ensure appropriate consent is obtained for video recording. Prioritize student privacy by ensuring recordings are only used for the intended educational purpose and are not shared inappropriately. Focus on non-identifiable movements if possible. Choose categories that promote positive body image and safe physical activity.

By carefully considering these factors, you select appropriate poses or movements for your Teachable Machine Pose Projects, ensuring they are educationally valuable, engaging, and ethically sound.

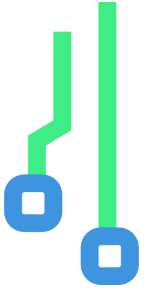
5.1.3 Defining project success criteria

Establishing clear success criteria before you begin your Teachable Machine Pose Project is crucial for evaluating its effectiveness and determining whether it has achieved its intended purpose. These criteria provide a benchmark against which you can measure your project's performance and identify areas for improvement. They also help maintain focus during the development process and ensure you remain on track to achieve your goals. Here's a guide to defining effective project success criteria for pose projects:

- **Accuracy and performance metrics:** Setting targets for your pose recognition model's accuracy and performance is a common way to define success.

Funded by the European Union

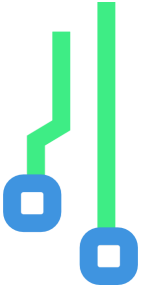
Funded by the European Union. However, the views expressed belong to the author(s) alone and do not necessarily reflect the views of the European Union or the Erasmus+ National Agency -INDIRE. Neither the European Union nor the granting administration can be held responsible for them. Project N°: 2024-1-IT02-KA220-SCH-000249373



    - **Overall accuracy:** Determine the minimum acceptable percentage of correct classifications. For instance, a goal might be to achieve 85% overall accuracy, meaning the model correctly classifies 85% of the poses presented to it.
    - **Class-specific accuracy:** For more critical or challenging poses (e.g., distinguishing subtle differences in physical exercises), specific accuracy targets can be set for each. A higher accuracy might be required for identifying correct form in a sports training project.
    - **Precision and recall (Simplified):** These metrics offer a more detailed understanding of your model's performance. "Precision" indicates how often the model was correct when it said a pose belonged to a certain class. "Recall" measures how often the model correctly identified a pose that *actually* belonged to a certain class. A balanced model typically performs well on both.
    - **Response time:** If real-time pose recognition is required (e.g., for interactive games), set a target for the maximum acceptable response time. This measures the time taken for the model to process a pose and provide a classification.
- **Functionality and usability:** Define criteria related to your project's functionality and usability, especially if it's intended for a specific application or user group.
    - **Ease of use:** If your project includes a user interface, criteria for its ease of use and intuitiveness must be defined. Consider if users can easily interact with the model and understand its output.
    - **Integration:** For projects intended for integration with another system or application, define criteria for successful integration. Verify if it seamlessly connects and exchanges data with the other system.
    - **Responsiveness:** Evaluate how smoothly the model tracks and responds to human movement.
- **Educational impact (If applicable):** For projects designed for educational purposes, define criteria related to their impact on student learning.
    - **Learning outcomes:** Does the project assist students in achieving the intended learning outcomes? Can students demonstrate improved knowledge or skills after using the project, such as enhanced motor skills, understanding of body mechanics, or observational abilities?
    - **Engagement:** Does the project engage students and motivate them to learn? Do students find the project interesting and enjoyable?
    - **Student feedback:** Collect feedback from students regarding their experience with the project. Do they find it helpful, informative, or enjoyable?

Funded by the European Union

Funded by the European Union. However, the views expressed belong to the author(s) alone and do not necessarily reflect the views of the European Union or the Erasmus+ National Agency -INDIRE. Neither the European Union nor the granting administration can be held responsible for them. Project N°: 2024-1-IT02-KA220-SCH-000249373



- **Technical requirements:** Define criteria related to any specific technical requirements for your project.
    - **Platform compatibility:** Does the project operate correctly on the intended platforms or devices (e.g., specific webcams, browser versions)?
    - **Lighting and background robustness:** Does the model perform well under varying lighting conditions or against different backgrounds?
    - **Resource usage:** Does the project utilize resources efficiently? Does it run smoothly without consuming excessive processing power or memory?
- **Ethical considerations:** Incorporate ethical considerations into your success criteria.
    - **Privacy protection:** Does the project protect user privacy and handle pose data responsibly, perhaps by processing video locally or ensuring immediate deletion?
    - **Fairness:** Does the model perform equitably across different body types or postures, minimizing unintended biases?

Examples of success criteria for Pose Projects:

- "The pose recognition model achieves an overall accuracy of 85% in classifying five distinct yoga poses."
- "Students using the physical education feedback project demonstrate a 10% improvement in correctly performing a specific exercise after using the tool."
- "The interactive storytelling application accurately triggers plot points based on three defined character gestures."

By defining clear, measurable, and relevant success criteria, you effectively guide the development of your Teachable Machine Pose Project and ensure it meets your intended goals.

5.2 Data collection and preparation: Building your dataset for poses

Data forms the lifeblood of any Machine Learning model. The quality, quantity, and diversity of your pose data directly impact the performance and accuracy of your Teachable Machine project. Therefore, planning a robust data collection strategy is essential for building a successful model.

5.2.1 Gathering pose data: Sources and methods

The quality and diversity of your pose dataset are paramount to the success of your Teachable Machine Pose Project. A well-constructed dataset enables your model to learn effectively and

Funded by the European Union

Funded by the European Union. However, the views expressed belong to the author(s) alone and do not necessarily reflect the views of the European Union or the Erasmus+ National Agency -INDIRE. Neither the European Union nor the granting administration can be held responsible for them. Project N°: 2024-1-IT02-KA220-SCH-000249373

make accurate predictions. This section outlines various sources and methods for gathering pose data:

- **Webcam capture:** Teachable Machine provides a convenient feature allowing direct pose capture using your computer's webcam. This method proves particularly useful for collecting poses performed by yourself, students, or volunteers directly in the classroom.
    - **Advantages:**
        - Data collection is easy and quick for live input.
        - Direct control over the pose, lighting, and background is possible.
        - Real-time capture of specific movements or static poses is supported.
    - **Considerations:**
        - Ensure consistent lighting and a clear background for optimal pose detection.
        - Privacy and consent are crucial when recording individuals.
        - The subject must be visible to the webcam, typically from the waist or full body.

💡**Teacher's tip:**

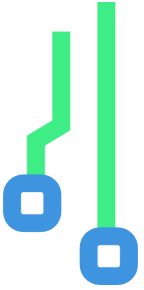
The perfect physical setup for pose recognition:: To ensure PoseNet detects all 17 skeletal keypoints accurately, follow these setup rules:

- **Distance:** The student must stand at least 2 meters (6–7 feet) away from the webcam so the AI can track the entire body skeleton from head to toe.
- **Clear Background:** Avoid standing in front of crowded bookshelves or posters; background shapes can be misidentified as human joints.
- **Frontal Lighting:** Ensure light shines on the front of the student. Strong backlighting turns the student into a silhouette, making joint detection difficult.

- **Pre-recorded video clips:** Using existing video clips of individuals performing various poses or movements can be a valuable method for collecting diverse data. You can extract individual frames or short segments from these videos.
    - **Advantages:**
        - Access to a wide variety of movements not easily reproducible on demand is granted.

Funded by the European Union

Funded by the European Union. However, the views expressed belong to the author(s) alone and do not necessarily reflect the views of the European Union or the Erasmus+ National Agency -INDIRE. Neither the European Union nor the granting administration can be held responsible for them. Project N°: 2024-1-IT02-KA220-SCH-000249373



        - Time and effort are saved compared to recording all poses yourself.
        - Access to specialized movements (e.g., sports, dance) is provided.
    - **Considerations:**
        - Be mindful of copyright restrictions and usage rights for video content.
        - Video quality and consistency (e.g., resolution, camera angle) may vary.
        - Careful filtering and selection of relevant video segments are necessary.
- **Pose augmentation (Advanced concept):** This technique involves artificially increasing the size and diversity of your pose dataset by applying various transformations to existing pose data. This can be a valuable method for improving your model's performance.
    - **Examples of augmentation techniques (Often applied to underlying skeletal data, not raw video):**
        - **Slight rotations:** Small rotational changes to the pose data.
        - **Scaling:** Adjusting the size of the pose.
        - **Mirroring:** Flipping the pose horizontally (e.g., right arm becomes left arm).
        - **Adding noise:** Introducing slight random variations to joint positions to simulate natural human movement variability.
    - **Advantages:**
        - Increases the size and diversity of your dataset without collecting new poses.
        - Can improve your model's ability to generalize and handle variations in human movement.
        - Helps prevent overfitting (when the model learns the training data too well and performs poorly on new data).
    - **Considerations:**
        - This is generally more complex for pose data than for images or audio and often requires external tools to manipulate the underlying pose keypoints, not just the raw video. For primary teachers, focus on diverse real-world capture.
        - Apply augmentation techniques judiciously; ensure transformations remain realistic.

When gathering pose data, prioritizing ethical considerations, quality, diversity, and relevance is crucial. Ensure your poses are clearly visible, consistent, and representative of the movements your model must recognize.

Funded by the European Union

Funded by the European Union. However, the views expressed belong to the author(s) alone and do not necessarily reflect the views of the European Union or the Erasmus+ National Agency -INDIRE. Neither the European Union nor the granting administration can be held responsible for them. Project N°: 2024-1-IT02-KA220-SCH-000249373

5.2.2 Creating pose classes: Defining categories for your model

In Teachable Machine, "classes" represent the distinct categories or labels your pose recognition model learns to identify. Clearly and accurately defining these classes is a crucial step in preparing your dataset and ensuring your model effectively distinguishes between different poses or movements. Here's a guide to creating pose classes:

- **Clearly define your categories:** Before adding pose samples, take time to carefully define the categories your model will recognize. Each class must represent a specific posture, gesture, or movement relevant to your project goals. Ensure categories are well-defined, unambiguous, and mutually exclusive (to the extent possible). This means minimal overlap or confusion between categories. For example, if classifying basic exercises, classes might be "standing," "squat," and "lunge."
- **Determine the number of classes:** The number of classes needed depends on your project's complexity and the number of distinct poses or movements to recognize. Start with a manageable number, especially as a beginner. Additional classes can always be added later if needed. Consider the trade-off between the number of classes and the data required; more classes generally demand more data for effective model training.
- **Name your classes appropriately:** Assign clear, descriptive names to your classes that accurately reflect the poses or movements they represent. This aids organization and ensures easy understanding of each class's purpose. Use consistent naming conventions, for example, clear action verbs (e.g., "arms raised," "sitting cross-legged").
- **Create classes in Teachable Machine:** Teachable Machine provides a user-friendly interface for creating and managing classes. An area for adding new classes, renaming existing ones, or deleting classes is available. Follow the on-screen instructions to create your classes and assign appropriate names.
- **Consider ethical implications and privacy:** When working with pose data involving individuals, always be particularly mindful of ethical considerations. Obtain proper consent for video recording, especially from students. Prioritize privacy by ensuring recordings are only used for the intended educational purpose and are not stored or shared inappropriately. Use general poses that do not identify individuals if possible.
- **Review and refine your classes:** After creating your initial set of classes, carefully review them to ensure appropriateness for your project goals. Consider whether adding, removing, or renaming classes is necessary. Often, refining classes becomes helpful after starting data collection, as a better understanding of movement variations is gained.

Funded by the European Union

Funded by the European Union. However, the views expressed belong to the author(s) alone and do not necessarily reflect the views of the European Union or the Erasmus+ National Agency -INDIRE. Neither the European Union nor the granting administration can be held responsible for them. Project N°: 2024-1-IT02-KA220-SCH-000249373

By carefully defining and creating your pose classes, you establish a solid foundation for your Teachable Machine Pose Project, ensuring your model effectively learns to distinguish between the specified categories.

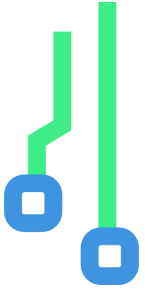
5.2.3 Augmenting your pose data: More examples, better learning

Pose data augmentation is a sophisticated technique for artificially increasing the size and diversity of your dataset of body postures and movements. This involves applying various transformations to existing pose samples to create new, slightly modified versions. This method can significantly improve your Teachable Machine Pose Project's robustness and generalization ability, helping it perform well on unseen data with variations in pose execution, individual differences, or camera angles. Here's a guide to pose data augmentation:

- **Why use pose augmentation?**
  - **Increased dataset size:** Augmentation allows the generation of more training data from existing poses, effectively expanding your dataset without needing to collect new samples. This is particularly useful when original pose recordings are limited or difficult to obtain.
  - **Improved generalization:** By introducing variations in your training data, augmentation helps the model learn more robust features and become less sensitive to specific details in the training poses. This enhances the model's ability to generalize to new, unseen poses that may differ slightly from the training data (e.g., a pose performed by a different person, or from a slightly different angle).
  - **Reduced overfitting:** Overfitting occurs when a model learns the training data too well, including its noise and idiosyncrasies, leading to poor performance on new data. Augmentation helps prevent overfitting by making the model less reliant on specific training examples and encouraging it to learn more generalizable features for diverse pose inputs.
- **Common augmentation techniques (Often more complex for poses):**
  - **Slight rotations and scaling:** Applying minor rotations (e.g., a few degrees) or scaling (making the person appear slightly closer or farther) to the captured pose helps the model recognize the pose regardless of minor positional shifts.
  - **Horizontal flipping (Mirroring):** Flipping the pose horizontally helps the model understand that a pose is the same regardless of which side is facing the camera (e.g., a left arm raised is the same as a right arm raised if mirrored).

Funded by the European Union

Funded by the European Union. However, the views expressed belong to the author(s) alone and do not necessarily reflect the views of the European Union or the Erasmus+ National Agency -INDIRE. Neither the European Union nor the granting administration can be held responsible for them. Project N°: 2024-1-IT02-KA220-SCH-000249373



- **Random cropping and translation:** Adjusting the bounding box around the person or slightly shifting their position within the frame helps the model focus on the pose itself rather than its exact position in the video frame.
- **Adding background noise:** While not directly "pose" augmentation, varying the background during data collection or digitally adding subtle background changes helps the model learn to ignore irrelevant visual information.

- **Applying pose data augmentation:**
  - **Teachable machine's built-in features:** Teachable Machine inherently handles some variations in pose detection through its underlying model. For direct augmentation, it relies on the diversity of input you provide across different angles and people.
  - **External tools and libraries (For advanced exploration):** For more systematic or complex pose augmentation, external tools might be used to manipulate video frames or underlying pose keypoint data (e.g., using libraries in Python for video processing and pose estimation). For primary teachers, the most practical approach for augmentation is to ensure the **diversity of original samples** collected (different students, slight variations in execution, different distances from the camera, varied lighting) rather than complex digital transformations.
- **Augmentation best practices:**
  - Apply augmentation techniques judiciously. Avoid transforming data to the point where the augmented pose no longer represents a realistic variation of the original.
  - Consider your project's specific requirements and choose augmentation techniques relevant to variations your model is likely to encounter in real-world use.
  - Monitor your model's performance on a validation set (data not used for training) to ensure augmentation improves generalization and does not hinder performance.

By ensuring diverse and robust data, either through varied direct capture or advanced augmentation, you enhance the robustness, accuracy, and generalization of your Teachable Machine Pose Projects, leading to more reliable and effective movement recognition models.

5.2.4 Preparing your data for Teachable Machine

Once your pose data is gathered and any desired augmentation strategies applied, the next step involves preparing it for use in Teachable Machine. Proper data preparation ensures your pose samples are in the correct format, organized effectively, and ready for training your ML model. Here's a guide to preparing your data:

Funded by the European Union

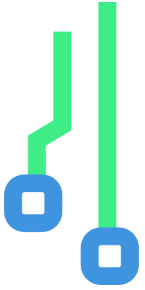
Funded by the European Union. However, the views expressed belong to the author(s) alone and do not necessarily reflect the views of the European Union or the Erasmus+ National Agency -INDIRE. Neither the European Union nor the granting administration can be held responsible for them. Project N°: 2024-1-IT02-KA220-SCH-000249373

- **Video recording quality:** Teachable Machine processes video streams to detect poses. Ensure your video recordings are clear, well-lit, and show the full body or relevant parts of the body clearly. Avoid blurry or low-resolution videos.
- **Consistent framing:** Maintain consistent framing and distance from the camera across all pose samples within a single class. While the model can handle some variation, consistency helps it learn more effectively. The subject should remain within the frame.
- **Data organization:** Organize your pose samples into "classes" that correspond to the distinct poses or movements your model will recognize. Teachable Machine automatically extracts pose data from your video input. You create a separate "class" for each pose (e.g., "Standing," "Sitting," "Arms Raised").
- **Background considerations:** While Teachable Machine's pose model (MoveNet) is robust to backgrounds, minimizing busy or cluttered backgrounds during recording can help the model focus on the person. A plain, consistent background is ideal.
- **Data cleaning:** Before training, review and clean your pose dataset. Remove any irrelevant, inappropriate, or corrupted video segments. Ensure no unwanted objects or people interfere with the primary pose.
- **Data splitting (Optional but recommended):** For more advanced Machine Learning practices, splitting your dataset into three subsets is recommended:
    - **Training set:** The largest subset, used to train the ML model.
    - **Validation set:** Used to evaluate model performance during training and tune hyperparameters.
    - **Test set:** Used to evaluate the final model's performance after training is complete. Teachable Machine does not require explicit splitting for basic use, but it is a good practice for rigorous model evaluation. A similar effect is achieved by reserving a portion of your data and not using it during the initial training phase. If data splitting is chosen, ensure similar class distribution across all subsets.
- **Uploading data to Teachable Machine:** Once your data is prepared, it is ready for upload to Teachable Machine. The platform provides user-friendly tools for uploading pose data, typically allowing you to:
    - Record pose samples directly using your webcam.
    - Upload video files from your computer. Follow the on-screen instructions to upload your data and associate it with the correct classes.

By carefully preparing your pose data, you ensure it is in optimal condition for training your Teachable Machine Pose Project, leading to better model performance and more reliable results.

Funded by the European Union

Funded by the European Union. However, the views expressed belong to the author(s) alone and do not necessarily reflect the views of the European Union or the Erasmus+ National Agency -INDIRE. Neither the European Union nor the granting administration can be held responsible for them. Project N°: 2024-1-IT02-KA220-SCH-000249373



💡Teacher's tip

Managing small spaces: If your classroom space is too constrained for full-body tracking, use these practical alternatives:

- **Upper-body/seated poses:** Train your model using upper-body gestures (arms, shoulders, head tilt) while students remain seated at their desks.
- **The hallway or gym option:** Allow student groups to use open corridors, the school yard, or the gymnasium during their 10-minute data collection phase.
- **Pre-recorded video sets:** Allow students to import pre-recorded video clips of movement routines instead of capturing live webcam streams .

5.3 Model training and evaluation: Bringing your pose AI to life

5.3.1 Training your pose model: Step-by-step

Once your pose dataset is prepared, the next step involves training your Machine Learning model in Teachable Machine. This training process entails feeding your pose data to the model, allowing it to learn and recognize the patterns and features that distinguish between the different pose classes you have defined. Teachable Machine simplifies this process, making it accessible even to those without coding experience. Here's a step-by-step guide to training your pose model:

- **Access your project:** Open Teachable Machine and access the Pose Project on which you have been working. Ensure that your pose data is uploaded and organized into the correct classes.
- **Review your data:** Before starting the training process, take a moment to review your data. Confirm its accuracy and ensure each class contains a sufficient number of representative pose samples. You can typically review the pose samples in each class directly within the Teachable Machine interface. Pay attention to variations in execution or background elements.
- **Initiate training:** Teachable Machine provides a clear button or control to start the training process. This is a prominent button, typically labeled "Train Model." Click this button to begin the training.

Funded by the European Union

Funded by the European Union. However, the views expressed belong to the author(s) alone and do not necessarily reflect the views of the European Union or the Erasmus+ National Agency -INDIRE. Neither the European Union nor the granting administration can be held responsible for them. Project N°: 2024-1-IT02-KA220-SCH-000249373

- **Training process:** Once training is initiated, Teachable Machine begins processing your pose data. The platform utilizes Machine Learning algorithms to analyze the pose keypoints detected in the video and identify key features that distinguish between classes. During training, the model adjusts its internal parameters to optimize its ability to classify poses correctly. Teachable Machine provides visual feedback on the training progress. This includes progress bars, messages, or animations indicating that training is underway. The duration of the training process depends on your dataset's size and complexity, as well as your computer's processing power or the platform's servers.
    - **How pose AI sees the body (The joint overlay):** Unlike Image Projects (which analyze pixels, clothing, and colors), Pose Projects use a model (MoveNet/PoseNet) that ignores visual appearances and maps 17 key human joints (elbows, shoulders, hips, knees). Tip: Loose or overly baggy clothing can obscure joint angles; encourage students to wear form-fitting clothes or adjust their positions so key joints remain clearly visible.
- **No coding required:** A key advantage of Teachable Machine is its handling of complex model training computations in the background. You do not need to write any code or possess specialized knowledge of Machine Learning algorithms to train your model.
- **Advanced training settings (Optional for deeper exploration):** While designed for simplicity, Teachable Machine offers "Advanced Settings" that allow users to fine-tune the training process. These settings can influence how the model learns and its final performance. The availability and specific nature of these settings might vary slightly with Teachable Machine platform updates.
    - **Epochs:** An epoch represents one complete pass through the entire training dataset during the training process. Increasing epochs generally allows more thorough learning, but also raises the risk of overfitting (where the model performs well on training data but poorly on new data). Teachable Machine allows epoch adjustment, providing control over training duration.

💡**Pose training tip :**

Because tracking 17 joints across moving frames is complex, pose models often require more training rounds. If your model hesitates or flips between classes, try increasing the

Funded by the European Union

Funded by the European Union. However, the views expressed belong to the author(s) alone and do not necessarily reflect the views of the European Union or the Erasmus+ National Agency -INDIRE. Neither the European Union nor the granting administration can be held responsible for them. Project N°: 2024-1-IT02-KA220-SCH-000249373

Epochs from 50 to 100 in the Advanced Settings to give the model more time to map joint relationships.

- **Batch size:** This refers to the number of data samples (pose frames, in this case) the model processes at a time during each parameter update. Adjusting batch size affects training speed and learning dynamics. Teachable Machine offers options for different batch sizes.
- **Learning rate:** A crucial parameter, the learning rate controls the step size the model takes to update its parameters based on calculated error (loss). A learning rate that is too high causes divergence and learning failure, while one that is too low significantly slows the training process. While Teachable Machine simplifies many aspects, advanced machine learning workflows involve this rate. If available as an option, proceed with caution.
- **Other hyperparameters:** Machine learning models possess parameters called hyperparameters that control the learning process. Teachable Machine exposes some of these for adjustment. Tuning these often requires experimentation and an understanding of machine learning principles.
- **Using advanced settings:** If choosing to use advanced settings, a systematic approach is generally recommended. Change one setting at a time, observe its impact on model performance, and meticulously track experiments and results. Effective use often demands a deeper understanding of machine learning concepts. For those new to machine learning, starting with default settings and gradually exploring advanced options as experience is gained is advisable.

- **Training tips:**
  - **Start with sufficient data:** Ensure adequate data in each class before training. A balanced dataset with a reasonable number of pose samples per class generally yields better results.
  - **Monitor progress (If available):** If Teachable Machine provides feedback on training progress, monitor it to understand how the model learns.
  - **Iterative training:** Training the model multiple times may be necessary, especially if initial results are unsatisfactory. Adjust your dataset, add more data, or modify classes, then retrain the model.

Funded by the European Union

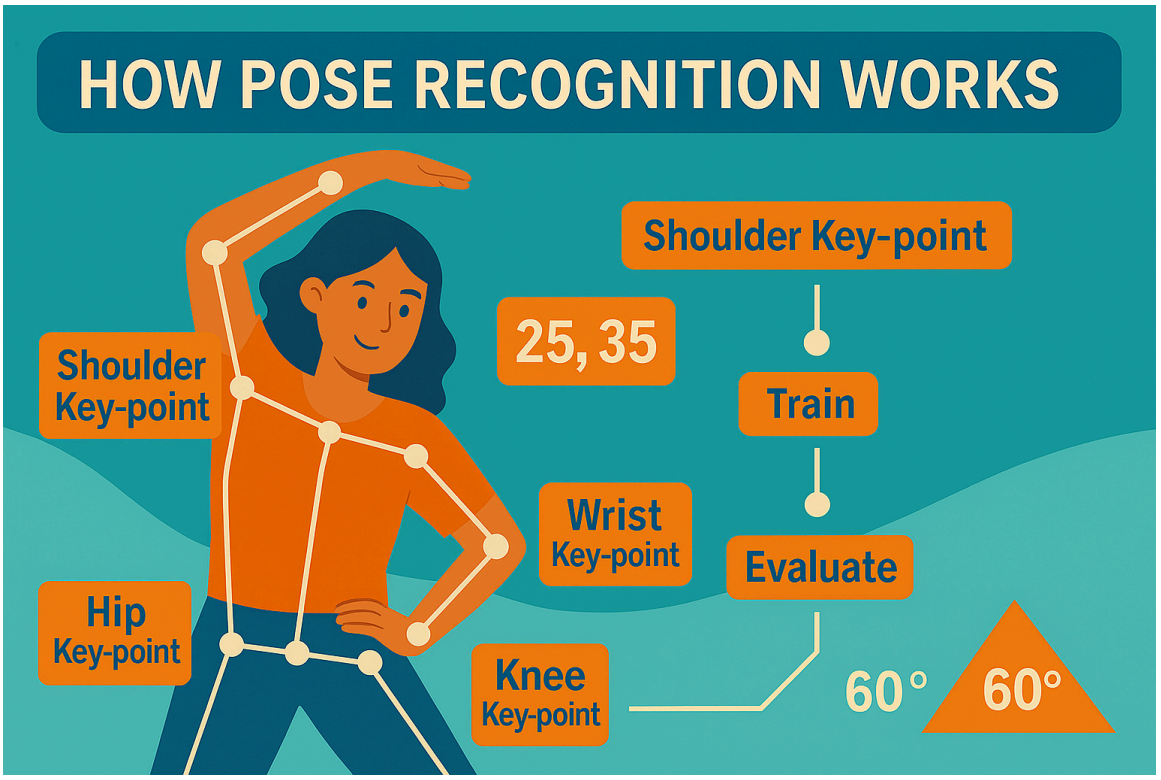
Funded by the European Union. However, the views expressed belong to the author(s) alone and do not necessarily reflect the views of the European Union or the Erasmus+ National Agency -INDIRE. Neither the European Union nor the granting administration can be held responsible for them. Project N°: 2024-1-IT02-KA220-SCH-000249373

- **Completion of training:** Once the training process concludes, Teachable Machine notifies you. Your pose recognition model is now trained and ready for evaluation and use.

Teachable Machine simplifies the training process, making it accessible to a wide range of users. By following these steps and ensuring a well-prepared dataset, you effectively train your pose model and begin exploring its capabilities.

How pose recognition works (Simplified):

Teachable Machine's pose model uses an algorithm based on key-points—specific coordinates on the human body (like joints). It captures relative positions and angles, turning them into numbers for training and prediction.



🧠 Simplified process

Funded by the European Union

Funded by the European Union. However, the views expressed belong to the author(s) alone and do not necessarily reflect the views of the European Union or the Erasmus+ National Agency -INDIRE. Neither the European Union nor the granting administration can be held responsible for them. Project N°: 2024-1-IT02-KA220-SCH-000249373

			
1. Webcam captures body posture	2. Key-points are detected	3. Patterns are analyzed	4. Model learns to classify movements

Pose recognition demonstrates how AI can interpret motion, but also highlights its limits—camera angle, lighting, and movement speed can all affect accuracy.

5.3.2 Evaluating model performance: Understanding accuracy and metrics

After training your pose model in Teachable Machine, evaluating its performance is crucial to determine how well it works and whether it meets your project's success criteria. Evaluation involves testing the model with pose data it has not seen during training and analyzing its predictions. Here's a guide to evaluating model performance for pose projects:

- **Teachable machine's preview:** A built-in preview feature in Teachable Machine allows for quick testing of your trained model. You can use your webcam to provide new pose input or upload existing video clips, then observe how the model classifies them. This preview offers an intuitive way to gauge your model's performance quickly. Observe if the model correctly identifies postures or movements in the input provided. Pay attention to any misclassifications or instances where the model appears uncertain.
- **Understanding accuracy:** Accuracy stands as a common metric for evaluating classification models. It represents the overall proportion of correct predictions made by the model. For example, if you provide the model with 100 test pose samples and it correctly classifies 85, the accuracy is 85%. While accuracy is a useful metric, its limitations, especially with imbalanced datasets (where some classes have significantly more data than others), are important to consider.
- **Confusion matrix:** A confusion matrix provides a more detailed breakdown of your model's performance. This table shows the number of correct and incorrect predictions for each class. The rows typically represent the actual classes, while the columns represent the predicted classes. Analyzing the confusion matrix helps identify which classes the model struggles to distinguish and where it makes the most errors.

Funded by the European Union

Funded by the European Union. However, the views expressed belong to the author(s) alone and do not necessarily reflect the views of the European Union or the Erasmus+ National Agency -INDIRE. Neither the European Union nor the granting administration can be held responsible for them. Project N°: 2024-1-IT02-KA220-SCH-000249373

- **Precision and recall (Simplified):** Other important metrics, precision and recall, offer a nuanced understanding of your model's performance, particularly with imbalanced datasets.
    - **Precision:** Measures the proportion of positive identifications that were actually correct. It answers: "Of all the times the model said it was a certain class, how often was it right?"
    - **Recall:** Measures the proportion of actual positives that were correctly identified by the model. It answers: "Of all the times it *actually* was a certain class, how often did the model say so?" A high precision score indicates the model excels at avoiding false positives, while a high recall score signifies it is good at identifying all instances of a particular class.
- **F1-score (Simplified):** The F1-score combines precision and recall into a single value. It provides a balanced measure of a model's performance, especially when an imbalance exists between classes. Generally, a higher F1-score indicates better performance.
- **Evaluation best practices:**
    - **Use a separate test set:** For an unbiased evaluation, testing your model on data it has not encountered during training is crucial. This is known as a test set.
    - **Evaluate on representative data:** Ensure your test data accurately represents the real-world poses your model will encounter. This means including variations in person, clothing, lighting, and background.
    - **Consider your project goals:** The most important metrics for evaluating your model depend on your project's specific goals. If avoiding false positives is critical (e.g., a system to alert incorrect posture), prioritize precision. If identifying all instances of a class is crucial (e.g., tracking all occurrences of a specific dance move), prioritize recall.
    - **Iterative evaluation:** Evaluation is an iterative process. You may need to evaluate your model multiple times, adjust your dataset or training process, and then re-evaluate to see if changes have improved performance.

By carefully evaluating your model's performance using appropriate metrics and best practices, you gain a clear understanding of its strengths and weaknesses and make informed decisions on how to improve it.

Funded by
the European Union

Funded by the European Union. However, the views expressed belong to the author(s) alone and do not necessarily reflect the views of the European Union or the Erasmus+ National Agency -INDIRE. Neither the European Union nor the granting administration can be held responsible for them. Project N°: 2024-1-IT02-KA220-SCH-000249373

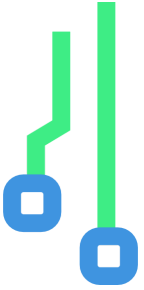
5.3.3 Troubleshooting and improving your model

Encountering challenges and areas for improvement is common when training and evaluating your Teachable Machine Pose Project. Your model might not perform as expected initially, or you might notice specific weaknesses in its predictions. Troubleshooting and iteratively improving your model are essential parts of the Machine Learning process. Here's a guide to help you:

- **Identify common problems:**
  - **Low accuracy:** The model makes a large number of incorrect predictions.
  - **Overfitting:** The model performs well on the training data but poorly on new, unseen data. This indicates that the model has learned the training data too well, including its noise and idiosyncrasies.
  - **Confusion between classes:** The model struggles to distinguish between certain classes, often misclassifying one pose as another. This is common when poses are very similar or transitions between them are unclear.
  - **Bias:** The model performs significantly better on some groups or body types than others, indicating potential bias in the data or model.
- **Strategies for troubleshooting and improvement:**
  - **Increase data quantity:** If your model exhibits low accuracy, increasing the amount of training data is a common solution. Collect more pose samples for each class, ensuring a balanced dataset. A larger dataset provides the model with more information to learn from, improving its generalization ability.
  - **Improve data quality and diversity:** Review your existing data to identify any low-quality or unrepresentative pose samples. Remove recordings that are blurry, poorly lit, or do not clearly show the intended pose. Increase your dataset's diversity by capturing poses from different individuals, in various lighting conditions, and from slightly different angles. Consider adding examples where the pose is partially obscured or performed with slight variations, if relevant to your application.
  - **Refine your classes:** If your model confuses certain classes, review your class definitions to ensure clarity and distinctiveness. If necessary, merge very similar classes or create more specific sub-classes to reduce ambiguity. Ensure pose samples within each class are representative and do not significantly overlap with other classes.
  - **Address overfitting:** When your model is overfitting, consider these approaches:

Funded by the European Union

Funded by the European Union. However, the views expressed belong to the author(s) alone and do not necessarily reflect the views of the European Union or the Erasmus+ National Agency -INDIRE. Neither the European Union nor the granting administration can be held responsible for them. Project N°: 2024-1-IT02-KA220-SCH-000249373



- **Data augmentation (as discussed in 5.2.3):** Augmentation, by introducing synthetic variations, helps prevent overfitting.
- **Simplify the model (If applicable):** While Teachable Machine abstracts much of the model architecture, in more advanced ML, simplifying the model can sometimes help with overfitting.
- **Early stopping (If available):** Some training systems incorporate "early stopping," where training halts when performance on a validation set begins to degrade.

- **Check for bias:** Carefully analyze your dataset for potential sources of bias. Ensure your data represents the diversity of individuals and pose executions your model is intended to process. If bias is identified (e.g., poor performance for certain body types or skin tones), collect more diverse data to balance your dataset and mitigate the bias. Evaluate your model's performance across different groups to identify and address any disparities.
- **Iterative training and evaluation:** Troubleshooting and improvement are iterative processes. Make small changes to your dataset, training process, or class definitions, then retrain and re-evaluate your model. Meticulously track the changes made and their impact on performance. Use evaluation metrics (accuracy, precision, recall, confusion matrix) to guide your improvements.
- **Seek help and resources:** If you struggle to improve your model's performance, do not hesitate to seek help and resources. Online forums, tutorials, and communities offer valuable insights and guidance. Teachable Machine's documentation and support resources also provide helpful tips and troubleshooting advice.

By systematically troubleshooting and iteratively improving your model, you overcome challenges, enhance its performance, and achieve desired results in your Teachable Machine Pose Projects.

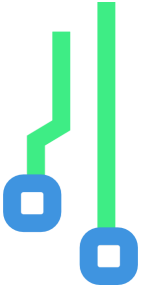
5.4 Applications in the classroom: Pose AI in action

5.4.1 Interactive learning activities with pose recognition

Pose recognition technology, powered by Teachable Machine, serves as a valuable tool for creating engaging and interactive learning activities that involve physical movement in the classroom. Incorporating pose-based AI into your lessons provides students with hands-on

Funded by the European Union

Funded by the European Union. However, the views expressed belong to the author(s) alone and do not necessarily reflect the views of the European Union or the Erasmus+ National Agency -INDIRE. Neither the European Union nor the granting administration can be held responsible for them. Project N°: 2024-1-IT02-KA220-SCH-000249373

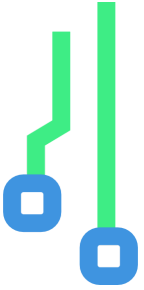


experiences, enhances their understanding of body mechanics, and fosters a more dynamic learning environment. Here are some examples of interactive learning activities with pose recognition:

- **Fitness and exercise guides:** Design an activity where students use a Teachable Machine model to check their form while performing various exercises. Students can receive immediate feedback on whether their posture matches a "correct" example, promoting proper technique and preventing injury. This is particularly useful in physical education classes or for guided stretching routines.
- **Dance and performance practice:** Develop an interactive tool where students practice dance moves or theatrical poses. A Teachable Machine model can be trained to recognize specific choreographies or character stances, providing feedback on accuracy. This allows students to refine their performance independently, making artistic practice more dynamic.
- **Interactive storytelling and Role-Playing:** Pose recognition can spark creativity and storytelling activities. Students can utilize a Teachable Machine model to trigger different narrative paths or character actions based on their physical gestures or dramatic poses. This enhances students' imagination, physical expression, and narrative abilities, making stories come alive through movement. For example, striking a "hero pose" might advance the story to a moment of triumph.
- **Accessibility and communication tools:** Explore creating basic pose-based communication tools for students with specific needs. A Teachable Machine model could be trained to recognize simple gestures (e.g., "yes," "no," "more") that then trigger corresponding responses or actions on a screen. This fosters inclusive communication and provides alternative interaction methods.
    - **Inclusive AI discussion:** Enrich this activity by training pose models with users performing gestures from a seated position or a wheelchair.. Ask your students: "If an AI exercise app is trained only on standing adults, how accessible is it for people with mobility differences?" This links physical projects directly with inclusive technology design.
- **Gesture-controlled interfaces:** Engage students in designing simple gesture-controlled interfaces for educational games or applications. Students could train a Teachable Machine model to recognize specific hand movements (e.g., wave left/right, point up/down) to control an on-screen character or navigate a presentation. This introduces concepts of human-computer interaction and design.

Funded by the European Union

Funded by the European Union. However, the views expressed belong to the author(s) alone and do not necessarily reflect the views of the European Union or the Erasmus+ National Agency -INDIRE. Neither the European Union nor the granting administration can be held responsible for them. Project N°: 2024-1-IT02-KA220-SCH-000249373



- **Art and sculpture analysis:** Students might use pose recognition to analyze the postures in famous artworks or sculptures, training a model to identify common poses or historical artistic conventions. This links technology with art history and visual analysis.

These interactive learning activities demonstrate the potential of pose recognition to transform the classroom experience, making it more engaging, interactive, and effective, especially for kinesthetic learners.

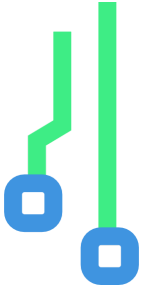
5.4.2 Integrating pose AI into subject-specific lessons

Teachable Machine's pose recognition capabilities integrate seamlessly into a wide range of subject-specific lessons, enriching the curriculum and providing students with unique learning experiences. By tailoring pose AI projects to specific subjects, educators enhance student engagement, promote deeper understanding, and foster interdisciplinary learning. Here are some examples of how to integrate pose AI into different primary school subjects:

- **Physical education and health:**
  - **Exercise form analysis:** Projects can be created that classify different physical exercises, such as squats, lunges, or jumping jacks, based on correct or incorrect form. Students train a model to recognize precise movements, receiving immediate feedback on their technique. This supports proper physical development and injury prevention.
  - **Yoga and stretching guides:** Develop projects that recognize specific yoga poses or stretching routines. Students can use a model to check if they are holding a pose correctly, enhancing their understanding of body alignment and flexibility.
- **Performing arts (Dance, drama, mime):**
  - **Choreography practice:** Projects can be developed that classify and verify specific dance moves or sequences. Students train a model to recognize steps, receiving feedback on their execution. This aids independent practice and precision in performance.
  - **Dramatic expression:** Create projects that classify different emotional or character poses related to storytelling or drama. Students train a model to recognize a "happy pose," a "sad pose," or a specific character's stance from a play. This enhances understanding of non-verbal communication and stage presence.

Funded by the European Union

Funded by the European Union. However, the views expressed belong to the author(s) alone and do not necessarily reflect the views of the European Union or the Erasmus+ National Agency -INDIRE. Neither the European Union nor the granting administration can be held responsible for them. Project N°: 2024-1-IT02-KA220-SCH-000249373



- **Mime and gesture studies:** Students can explore mime by training models to recognize iconic gestures or actions, understanding how specific body language conveys meaning.

- **Social studies and cultural studies:**
  - **Cultural dance forms:** Projects can be created that classify basic poses or steps from different cultural dances. Students learn about global cultures through movement, training models to recognize specific cultural dance elements.
  - **Historical gestures:** Explore projects that classify historical gestures or poses (e.g., salutes, respectful bows from different eras). Students gain insight into historical social norms and communication.
- **Cross-curricular explorations (Linking to STEM and beyond):**
  - **Human-computer interaction (Introductory):** Students can design simple gesture-controlled interfaces for educational games or presentations. This involves training a model to recognize hand movements (e.g., waving left/right, pointing up/down) to control on-screen elements, introducing fundamental concepts of interaction design.
  - **Biomechanics (Simplified):** Explore basic biomechanical concepts by classifying efficient vs. inefficient poses for activities like lifting or pushing. This helps students understand the physics of movement.
  - **Storytelling with movement:** Integrate pose recognition into interactive storytelling activities. Students utilize a Teachable Machine model to trigger different narrative paths or character actions based on their physical gestures or dramatic poses. This enhances imagination, physical expression, and narrative abilities, making stories come alive through movement.

These examples illustrate pose AI's versatility in education, demonstrating its adaptability to enhance learning across various subjects. Integrating Teachable Machine Pose Projects into subject-specific lessons allows educators to create engaging, interactive, and effective learning experiences for their students, particularly focusing on movement and physical expression.

Funded by
the European Union

Funded by the European Union. However, the views expressed belong to the author(s) alone and do not necessarily reflect the views of the European Union or the Erasmus+ National Agency -INDIRE. Neither the European Union nor the granting administration can be held responsible for them. Project N°: 2024-1-IT02-KA220-SCH-000249373

Summary table: Subject-specific pose recognition projects

Subject	Classroom project idea	Learning goal
Physical education and health	Analyze form in squats, lunges, jumping jacks, or guide yoga stretches.	Support proper movement technique, posture alignment, and injury prevention.
Performing arts	Verify dance choreography steps or distinguish emotional body language poses.	Refine performance precision and explore non-verbal emotional expression
Social studies and cultural studie	Classify traditional cultural dance postures or historical respectful bows/salutes.	Connect physical movement with cultural history and non-verbal social norms.
Cross-curricular explorations (Linking to STEM and beyond)	Design gesture controllers (waving left/right) to steer Scratch game characters.	Understand human-computer interaction, sensor inputs, and basic biomechanics.

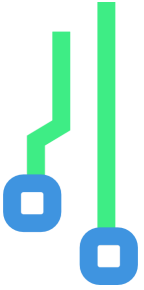
5.4.3 Assessment strategies using pose-based AI projects

Pose-based AI projects, created with Teachable Machine, serve as valuable tools for various assessment strategies to evaluate student learning, provide feedback, and track progress, particularly in areas involving physical demonstration, body mechanics, or non-verbal communication. These projects offer unique opportunities for authentic assessment, allowing students to demonstrate understanding and skills in practical and engaging ways. Here are some examples of assessment strategies using pose-based AI projects:

- **Performance-based assessment (Physical skills):** Utilizing pose-based AI projects assesses students' ability to apply knowledge and skills in practical physical situations. Present students with exercises, dance routines, or movements requiring them to use their models for self-correction or demonstration. Evaluate their performance based on model prediction accuracy and effectiveness, as well as their ability to interpret and utilize results. For example, students could use a model to check their yoga poses, or demonstrate correct form for a gymnastic move.

Funded by the European Union

Funded by the European Union. However, the views expressed belong to the author(s) alone and do not necessarily reflect the views of the European Union or the Erasmus+ National Agency -INDIRE. Neither the European Union nor the granting administration can be held responsible for them. Project N°: 2024-1-IT02-KA220-SCH-000249373



- **Project-based assessment:** Assigning pose-based AI projects as a major assessment task requires students to design, develop, and evaluate their own pose recognition models. Assess students' understanding of concepts and skills involved, such as data collection (recording poses), model training, evaluation, and application. Evaluate the quality of their projects, including model accuracy, functionality, and creativity. Provide opportunities for students to present their projects, explaining design choices and findings. Project-based assessment allows for a holistic evaluation of student learning and provides them with a sense of ownership over their work.
- **Formative assessment:** Pose-based AI projects can be integrated into formative assessment activities to monitor student learning and provide ongoing feedback. Use Teachable Machine models to create interactive exercises or activities that allow students to check their understanding of physical concepts or practice specific movements. Provide students with immediate feedback on their performance, identifying areas needing additional support. Formative assessment with pose AI helps students track progress and pinpoint areas for improvement in physical skills.
- **Self-assessment and peer assessment:** Encourage students to use pose-based AI projects for self-assessment and peer assessment. This promotes metacognition, critical thinking, and collaboration skills. Students use their models to evaluate their own physical performance or provide feedback to classmates on their pose projects. Provide students with clear criteria and guidelines for self-assessment and peer assessment, focusing on constructive feedback.
- **Portfolio assessment:** Include pose-based AI projects in student portfolios to showcase their learning and achievements over time. Portfolios offer a comprehensive view of student growth and development, highlighting strengths, skills, and progress in physical and AI-related areas. Students select their best projects for inclusion and reflect on their learning experiences.

Examples of assessment tasks for Pose Projects:

- "Design a pose recognition model that classifies three different stretches, and use it to guide your classmates in a warm-up routine."
- "Develop a pose-based game where students correctly perform poses to advance levels, demonstrating understanding of physical movements."
- "Create a performance-based assessment where students use a pose recognition model to demonstrate correct technique for a specific dance step from a cultural dance."

Funded by the European Union

Funded by the European Union. However, the views expressed belong to the author(s) alone and do not necessarily reflect the views of the European Union or the Erasmus+ National Agency -INDIRE. Neither the European Union nor the granting administration can be held responsible for them. Project N°: 2024-1-IT02-KA220-SCH-000249373

- "Use a Teachable Machine model to build an interactive activity helping students distinguish between 'active' and 'relaxed' body language in communication scenarios."

By incorporating pose-based AI projects into a variety of assessment strategies, educators create authentic, engaging, and effective ways to evaluate student learning and promote deeper understanding in areas related to movement, physical expression, and kinesthetic learning.

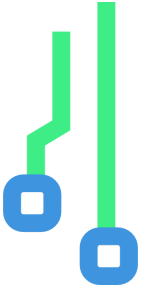
Funded by the European Union. However, the views expressed belong to the author(s) alone and do not necessarily reflect the views of the European Union or the Erasmus+ National Agency -INDIRE. Neither the European Union nor the granting administration can be held responsible for them. Project N°: 2024-1-IT02-KA220-SCH-000249373

M{AI}L

Module 6: Classroom integration strategies: Pedagogical approaches

Funded by the European Union. However, the views expressed belong to the author(s) alone and do not necessarily reflect the views of the European Union or the Erasmus+ National Agency -INDIRE. Neither the European Union nor the granting administration can be held responsible for them. Project N°: 2024-1-IT02-KA220-SCH-000249373

Funded by
the European Union



Integrating new technologies like AI into the classroom requires thoughtful pedagogical approaches. This module focuses on practical strategies for effectively incorporating Teachable Machine into your teaching practices, ensuring alignment with curriculum goals, fostering student-centered learning, and navigating ethical considerations. We also address common challenges reported by educators and offer solutions to support successful AI integration.

6.1 Integrating Teachable Machine into your lesson planning

Designing effective learning experiences with Teachable Machine involves careful consideration of how this tool aligns with your curriculum goals and enhances existing pedagogical practices. It provides a unique opportunity to transform traditional lessons into dynamic, interactive explorations.

- **Aligning Teachable Machine projects with Curriculum goals:** Successful integration begins by ensuring Teachable Machine projects directly support your subject-specific learning objectives. Consider how using image, audio, or pose recognition can help students grasp concepts in science or language arts more concretely. For instance, classifying animal sounds (audio project) or identifying different types of leaves (image project) directly supports biology lessons. Building a model to recognize correctly pronounced words (audio project) directly reinforces language acquisition. By clearly linking projects to learning outcomes, students engage with technology purposefully.
- **Developing engaging and interactive activities:** Teachable Machine inherently promotes active, hands-on learning. Engage students in creating their own ML models, allowing them to participate in data collection, training, and evaluation. This experiential approach fosters deeper understanding and engagement compared to passive learning methods. Activities where students design models to solve a simple classroom problem, or create interactive quizzes using their own data, significantly increase motivation.
- **Incorporating Teachable Machine into lesson plans:** Integrating Teachable Machine into existing lesson plans should be seamless. It can serve as an introductory activity to a new topic, a tool for reinforcing concepts, or a method for project-based learning. For example, a science lesson on ecosystems could start with students training an audio model to identify different animal calls from a specific habitat. A language arts lesson on verbs might involve a pose project where students demonstrate and classify action verbs. By simplifying the creation of materials and exercises, Teachable Machine can also help reduce teachers' workload, freeing up time for focused instruction and student interaction.

Funded by the European Union

Funded by the European Union. However, the views expressed belong to the author(s) alone and do not necessarily reflect the views of the European Union or the Erasmus+ National Agency -INDIRE. Neither the European Union nor the granting administration can be held responsible for them. Project N°: 2024-1-IT02-KA220-SCH-000249373

📝**Teacher's guide:**

The 60-minute rapid lesson structure: To keep your lesson on schedule and prevent data collection from consuming the entire class period, follow this time-boxed flow:

- **0–10 min (Introduction & Ethics):** Present the driving question, explain what the AI will learn, and establish data consent/privacy rules.
- **10–25 min (Data Collection):** Students work in groups to capture or upload samples (strictly limited to 15 minutes).
- **25–35 min (Training):** Run the model training and observe the progress bar.
- **35–50 min (Testing & Iteration):** Test the model with new input, find prediction errors, and refine the dataset.
- **50–60 min (Debrief & Reflection):** Discuss model limitations, dataset bias, and practical takeaways.

6.2 Fostering student-centered learning with AI

Teachable Machine is a powerful tool for shifting the classroom dynamic towards a student-centered approach. It empowers students to become active participants in their learning journey, promoting inquiry, creativity, and critical thinking.

- **Promoting inquiry-based learning:** Teachable Machine encourages students to ask questions and investigate phenomena through experimentation. Students can formulate hypotheses about how a machine "learns," collect data to test their theories, and analyze the results. This approach transforms learning into a process of discovery, where students actively construct knowledge rather than passively receiving it. For example, students might inquire: "Can a machine tell the difference between a happy and a sad voice?" and then build an audio project to explore this.
- **Encouraging creativity and innovation:** The platform provides a unique avenue for students to express creativity and innovate. Students can design original projects that apply ML to solve problems they identify, or create new interactive experiences. This emphasis on creativity prepares students to be resourceful and adaptable, fostering an entrepreneurial spirit. Allowing students to create their own exercises using Teachable Machine is a direct example of fostering self-directed learning and innovative thinking.

Funded by the European Union

Funded by the European Union. However, the views expressed belong to the author(s) alone and do not necessarily reflect the views of the European Union or the Erasmus+ National Agency -INDIRE. Neither the European Union nor the granting administration can be held responsible for them. Project N°: 2024-1-IT02-KA220-SCH-000249373

- **Developing problem-solving and critical thinking skills:** Working with Teachable Machine directly strengthens students' problem-solving and critical thinking abilities. Students learn to break down complex tasks, analyze data, identify patterns, and design logical solutions. They also evaluate the effectiveness of their models, identify areas for improvement, and refine their approaches iteratively. This iterative process, involving troubleshooting and refinement, is fundamental to mastering complex challenges.

🗺️**Competency Mapping:**

When justifying AI integration in your curriculum, highlight these core competencies developed through Teachable Machine:

- **Critical thinking & debugging:** Analyzing why a model makes classification errors and systematically modifying data to improve accuracy.
- **Data literacy:** Understanding firsthand that machine "knowledge" depends entirely on the quality, balance, and diversity of human-provided data.
- **Collaborative problem-solving:** Working in teams to assign roles (data collector, trainer, tester, presenter) and resolve technical challenges.

6.3 Ethical considerations and responsible use of AI in the classroom

As AI becomes more prevalent in education, prioritizing ethical considerations and ensuring its responsible and equitable use is crucial. Teachers play a vital role in guiding students to become ethical AI citizens.

- **Understanding ethical concerns in AI:** It is important to discuss potential ethical issues arising from AI systems.
  - **Bias and fairness:** AI systems can sometimes perpetuate or even amplify existing societal biases present in the data they are trained on. Helping students understand how bias can enter AI models (e.g., from biased data or flawed algorithms) is crucial. Encouraging critical thinking about mitigating bias and promoting fairness in AI applications is a key step.

Funded by the European Union

Funded by the European Union. However, the views expressed belong to the author(s) alone and do not necessarily reflect the views of the European Union or the Erasmus+ National Agency -INDIRE. Neither the European Union nor the granting administration can be held responsible for them. Project N°: 2024-1-IT02-KA220-SCH-000249373

- **Privacy and data security:** The use of AI in education often involves collecting and using student data. Emphasize the importance of data privacy and security, ensuring student information is protected and handled responsibly. Discussing the potential risks of data breaches and the importance of responsible data handling practices is necessary.
- **Transparency and explainability:** Explore the concept of transparency in AI, which addresses the challenge of understanding how some AI models make decisions. Discussing the need for explainable AI (XAI) promotes a desire for systems that are more transparent and understandable.

- **Ethical guidelines for using AI in education:** Practical guidelines ensure responsible AI integration in the classroom.
  - **Responsible data collection and use:** When collecting data, especially images, audio, or poses of individuals, obtaining informed consent is imperative. Students must be fully aware of how their data will be used and stored. For projects involving children, consent from parents or legal guardians is essential. Avoiding personally identifiable information (PII) is also recommended unless strictly necessary.
  - **Promoting fairness and equity in AI applications:** Strive for diversity in datasets to mitigate bias. Be aware of potential bias sources during data collection and take steps to address them. Regularly evaluate your model's performance for fairness and identify any potential biases.
  - **Fostering critical thinking about AI ethics:** Students should be engaged in discussions about AI's ethical implications, fostering critical thinking and responsible decision-making. This includes topics like AI's impact on society and the workforce, potential risks and benefits, and the importance of using AI for good. Training students on responsible AI use and plagiarism awareness, especially with tools like ChatGPT, is vital.

  - **Assessment criteria: Evaluating the learning process:** Rather than grading solely on whether the final model achieves high accuracy, evaluate students on their understanding of the machine learning cycle:

    1. **Bias identification:** Did the student identify potential sources of bias or imbalance in their initial dataset?
    2. **Iterative refinement**: How many times did the team revise and improve their dataset after testing failed?

Funded by the European Union. However, the views expressed belong to the author(s) alone and do not necessarily reflect the views of the European Union or the Erasmus+ National Agency -INDIRE. Neither the European Union nor the granting administration can be held responsible for them. Project N°: 2024-1-IT02-KA220-SCH-000249373

Funded by the European Union

3. **Concept clarity:** Can the student explain the difference between the "Training Data" and the "Testing Input"?

6.4 Addressing common challenges

Integrating AI/ML tools into the classroom, while highly beneficial, often presents a unique set of challenges for teachers. Insights from numerous educators highlight common barriers and offer practical suggestions for overcoming them. Addressing these proactively ensures a smoother and more effective integration process.

- **Lack of practical training:** Many teachers report a significant barrier in the form of insufficient practical training on AI tools. To address this, specialized, hands-on training modules are highly recommended, tailored to specific subjects and age groups. Face-to-face workshops are particularly valuable during the initial adoption phase, complemented by ongoing online courses for specialized and continuous professional development.
- **Limited access to devices and the Internet:** A widespread challenge identified by educators is insufficient access to technological tools, including updated devices and reliable internet connectivity in schools. To mitigate this, improving school infrastructure and ensuring equitable access to high-tech resources like tablets, virtual reality glasses, and adequate internet bandwidth is crucial. Policies advocating for free access to digital tools and application licenses can also reduce barriers to adoption.

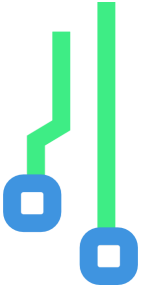
💡**Teacher's tip:**

The 'Plan B' contingency plan: If school internet slows down or webcams fail during class, use these backup approaches:

- **Pre-Loaded offline datasets:** Keep a folder of pre-selected images or audio files stored on a USB drive so students can use the "Upload" option instead of live webcam/mic recording.
- **Analogue AI ("Human Machine Learning"):** If technology fails completely, execute a human simulation activity where one student acts as the "Algorithm" and classmates present hand-drawn card examples to see if the "Algorithm" can infer the classification rule.

Funded by the European Union

Funded by the European Union. However, the views expressed belong to the author(s) alone and do not necessarily reflect the views of the European Union or the Erasmus+ National Agency -INDIRE. Neither the European Union nor the granting administration can be held responsible for them. Project N°: 2024-1-IT02-KA220-SCH-000249373



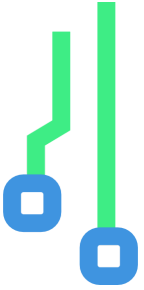
- **Time constraints for AI integration:** Teachers often express concerns about the tight schedules and curricular demands that limit their time for exploring and adapting AI tools. Addressing this requires allocating dedicated professional development time for AI workshops, allowing teachers to familiarize themselves with practical applications. Providing pre-planned lesson materials, such as handbooks or manuals, can also significantly reduce planning time.
- **Low digital literacy and confidence:** Some educators face challenges related to their own digital literacy and confidence in using AI tools effectively. To overcome this, providing mentorship and peer-sharing platforms is highly beneficial. Appointing AI mentors or coordinators within schools can offer on-demand support and guidance. A culture that embraces AI, supported by school management initiatives, also builds confidence and encourages responsible use.
- **Ethical concerns and lack of policies:** Concerns regarding the ethical use of AI, particularly for younger students, and the risk of misuse like plagiarism, are significant. It is essential to incorporate clear ethical guidelines and AI usage policies into training programs and school-wide digital policies. Training students themselves on responsible AI use and plagiarism awareness is also a key strategy.
- **Technical difficulties and lack of IT support:** Teachers frequently encounter technical difficulties, such as software failures and internet access problems. While many are resourceful, relying on personal research or peer support , the need for robust IT support is clear, especially in schools lacking dedicated IT departments. Improving technical support from IT departments or specialized technicians can alleviate these common challenges.

By addressing these identified challenges with targeted support, improved infrastructure, and continuous professional development, the successful and sustainable integration of AI/ML tools in classrooms becomes a more achievable goal.

Funded by
the European Union

Funded by the European Union. However, the views expressed belong to the author(s) alone and do not necessarily reflect the views of the European Union or the Erasmus+ National Agency -INDIRE. Neither the European Union nor the granting administration can be held responsible for them. Project N°: 2024-1-IT02-KA220-SCH-000249373

M{AI}L



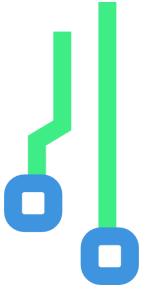
Funded by the European Union. However, the views expressed belong to the author(s) alone and do not necessarily reflect the views of the European Union or the Erasmus+ National Agency -INDIRE. Neither the European Union nor the granting administration can be held responsible for them. Project N°: 2024-1-IT02-KA220-SCH-000249373

M{AI}L

Module 7: Resources and support: Your guide to continued learning

Funded by the European Union. However, the views expressed belong to the author(s) alone and do not necessarily reflect the views of the European Union or the Erasmus+ National Agency -INDIRE. Neither the European Union nor the granting administration can be held responsible for them. Project N°: 2024-1-IT02-KA220-SCH-000249373

Funded by the European Union



Embarking on the journey of integrating AI and Machine Learning into your teaching is an ongoing process. This module serves as your guide to continued learning and support, providing references to essential online resources, pathways for further education in AI/ML, and methods for staying connected with the evolving landscape of educational technology.

7.1 Online resources for Teachable Machine

A wealth of resources exists online to support your use of Teachable Machine. These platforms offer documentation, tutorials, and communities where you can find answers, get inspiration, and connect with other educators.

- **Official Teachable Machine documentation:** For the most accurate and up-to-date information regarding the tool, refer to its official documentation. This resource provides comprehensive guides on features, troubleshooting, and best practices directly from its developers.
- **Tutorials and examples:** Numerous online tutorials and example projects demonstrate various applications of Teachable Machine. These can be found on platforms like YouTube, educational blogs, or specialized tech education websites. Exploring these can spark new ideas and offer alternative approaches to project creation.
- **Community forums and support groups:** Engaging with communities dedicated to AI in education or Teachable Machine users provides invaluable support. These forums allow you to ask questions, share your experiences, learn from peers, and find solutions to specific challenges you might encounter. Look for online groups on social media platforms or dedicated educational technology forums.
- **Recommended official and educational platforms**
    - Google Teachable Machine: Link
    - Google for Education – AI Resources: Link
    - Google Grow: Link
    - AI.Google: Link
    - AI4K12 Initiative: Link
    - European Schoolnet – AI in Education Toolkit: Link
    - UNESCO – Guidance for AI in Education: Link

Funded by the European Union

Funded by the European Union. However, the views expressed belong to the author(s) alone and do not necessarily reflect the views of the European Union or the Erasmus+ National Agency -INDIRE. Neither the European Union nor the granting administration can be held responsible for them. Project N°: 2024-1-IT02-KA220-SCH-000249373

7.2 Further learning in AI and Machine Learning

The field of Artificial Intelligence and Machine Learning is constantly evolving. Continuous learning ensures you stay updated and deepen your understanding of these transformative technologies. Consider these avenues for expanding your knowledge beyond this manual.

- **Recommended books and articles:** A vast body of literature covers AI and ML. Look for introductory books on AI for educators or articles from reputable educational technology journals. These resources often provide deeper theoretical understanding and insights into pedagogical implications.
- **Online courses and platforms:** Many reputable platforms offer free or paid online courses on AI and ML, tailored for various levels of expertise. Websites like Coursera, edX, Google's AI for Educators, or Scratch with AI Extensions provide structured learning paths. These courses can help solidify foundational knowledge and introduce more advanced concepts
- **Educational organizations and initiatives:** Several organizations are dedicated to promoting AI literacy and integration in education. Engaging with these initiatives can provide access to cutting-edge research, pilot programs, and networking opportunities with like-minded professionals. Look for local or national educational technology associations..
- **Professional development and MOOCs:** These platforms provide access to lesson ideas, ethics guidelines, open datasets, and teacher training materials tailored to different educational levels.
    - Elements of AI – University of Helsinki (Free) - Link
    - AI for Everyone – Coursera (Andrew Ng) - Link
    - AI in Education – FutureLearn - Link
    - University of Helsinki – Building AI - Link
    - Google AI Essentials Specialization - Link
    - Google Grow - Experience AI - Link

7.3 Ongoing support and updates

Staying current with AI and Machine Learning developments is crucial for effective integration into the classroom. Active engagement with the community and feedback mechanisms ensures continued support and improvement of resources.

Funded by the European Union

Funded by the European Union. However, the views expressed belong to the author(s) alone and do not necessarily reflect the views of the European Union or the Erasmus+ National Agency -INDIRE. Neither the European Union nor the granting administration can be held responsible for them. Project N°: 2024-1-IT02-KA220-SCH-000249373

- **Staying current with Teachable Machine developments:** The Teachable Machine platform itself undergoes periodic updates, introducing new features or refining existing ones. Regularly checking the official Teachable Machine website or subscribing to their newsletters ensures you are aware of the latest changes and can adapt your teaching accordingly.
- **Connecting with experts and educators:** Building a network with AI experts and fellow educators who are integrating AI into their classrooms provides a valuable support system. This can be achieved through professional development workshops, educational conferences, or online communities. Sharing experiences and challenges often leads to collaborative solutions and new insights.
    - **Educator communities and collaboration networks:** Encourage teachers to participate in MOOCs or webinars and to integrate reflections from these experiences into their teaching practices.
        - European Schoolnet (EUN) Teacher Networks.
        - eTwinning Projects on Digital Literacy and AI.
        - AI Educators Facebook and LinkedIn Groups.
        - National and local Erasmus+ partner networks.
        - OpenAI Educator Community.
- **Providing feedback and contributing to the community:** Your experience as an educator using Teachable Machine is invaluable. Providing feedback to the developers of the tool or to project M{AI}L helps improve resources for others. Contributing your successful lesson plans, exercises, or project ideas to educational communities or platforms also enriches the collective knowledge base.

7.4 Practical AI toolkits and educational software for the classroom

While Teachable Machine serves as an ideal no-code entry point for introducing machine learning, extending AI literacy into broader educational contexts often requires integrating complementary tools. Utilizing a variety of platforms allows educators to connect AI concepts with creative programming, visual arts, immersive virtual environments, and data storytelling across different student age groups.

Funded by the European Union

Funded by the European Union. However, the views expressed belong to the author(s) alone and do not necessarily reflect the views of the European Union or the Erasmus+ National Agency -INDIRE. Neither the European Union nor the granting administration can be held responsible for them. Project N°: 2024-1-IT02-KA220-SCH-000249373

To expand learning experiences beyond web-based classification models, teachers can incorporate the following practical toolkits into their STEAM and cross-curricular activities:

- **Scratch with AI extensions (MIT):** A creative block-based programming environment that enables primary and middle school students to code interactive games and animations driven by computer vision and audio recognition models].
- **PictoBlox with AI & ML extensions:** An advanced graphical and Python-based programming software designed for children and young adults to explore robotics, facial recognition, and smart hardware applications.
- **Delightex Edu and Merge Cube:** Augmented Reality (AR) and Virtual Reality (VR) learning environments that allow students to visualize, manipulate, and interact with complex 3D objects and AI-driven spatial simulations.
- **Teachable Machine combined with Google Colab:** A transitional pathway for secondary students moving from no-code visual model building to code-based Python scripting and machine learning libraries.
- **Canva for education:** A digital design platform supporting visual data storytelling, infographics creation, and responsible AI-assisted media integration for student project presentations.
- **Adobe Firefly:** A generative AI tool focused on creative arts that provides a safe framework for discussing responsible image generation, prompt engineering, and digital authorship in the classroom.

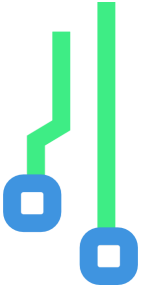
Integrating these tools allows educators to demonstrate the versatility of artificial intelligence beyond standalone machine learning exercises, fostering multidisciplinary creativity through art, design, and interactive coding.

7.5 Global ethical frameworks and AI policy guidelines

Ethical reflection must remain at the core of artificial intelligence education. As AI technologies become increasingly integrated into public life, educators need authoritative reference frameworks to guide classroom discussions regarding data privacy, algorithmic fairness, transparency, and human rights.

Funded by the European Union

Funded by the European Union. However, the views expressed belong to the author(s) alone and do not necessarily reflect the views of the European Union or the Erasmus+ National Agency -INDIRE. Neither the European Union nor the granting administration can be held responsible for them. Project N°: 2024-1-IT02-KA220-SCH-000249373



To ground classroom debates in established global standards, teachers can consult and adapt key international policies and ethical guidelines:

- **UNESCO recommendation on the ethics of Artificial Intelligence (2021):** A worldwide consensus framework emphasizing human dignity, fundamental freedoms, environmental protection, and gender equality in AI systems. Link
- **Ethics guidelines for trustworthy AI (European Commission, 2019)**: European guidelines highlighting seven key requirements for ethical AI, including human agency, technical safety, privacy, transparency, and non-discrimination. Link
- **OECD AI principles (2019)**: International principles advocating for innovative, trustworthy AI that respects human rights, democratic values, and fair societal development. Link
- **Council of Europe reports on AI and human rights:** Comprehensive analytical resources examining the impact of machine learning algorithms on freedom of expression, education, and democratic processes. Link

Educators can use these foundational frameworks to initiate meaningful classroom debates on digital citizenship, bias mitigation, and data protection.

Encouraging students to critically evaluate how algorithms influence social media feeds, search results, and public decision-making fosters informed, responsible, and active digital citizens.

7.6 Building sustainable practices and project dissemination

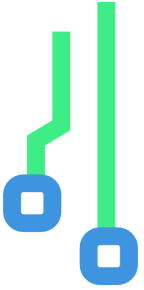
Achieving lasting educational impact requires moving beyond isolated classroom activities to establish sustainable AI teaching practices across the entire school community. Embedding AI literacy into everyday institutional culture ensures that educators support one another and that learning opportunities continue to expand over time.

To build a resilient and sustainable AI learning environment, schools and teachers should implement the following strategic practices:

- **Local teacher networks:** Establish professional learning communities within your school or local district where educators across different disciplines can collaborate, share lesson plans, and troubleshoot technical challenges.
- **School exhibitions and workshops:** Organize interactive student showcases, AI science fairs, or peer-led workshops where students present their trained models and

Funded by the European Union

Funded by the European Union. However, the views expressed belong to the author(s) alone and do not necessarily reflect the views of the European Union or the Erasmus+ National Agency -INDIRE. Neither the European Union nor the granting administration can be held responsible for them. Project N°: 2024-1-IT02-KA220-SCH-000249373



demonstrate their computational thinking skills to parents, school leaders, and classmates.

- **Peer-to-peer professional development:** Facilitate internal mentoring sessions where teachers experienced in using Teachable Machine train colleagues who are new to digital technology integration.
- **European documentation and dissemination:** Document project outcomes, student reflection sheets, and successful Learning Unit Plans (LUPs) to share across international educational networks, such as Erasmus+ platforms and European Schoolnet communities.

Funded by the European Union

Funded by the European Union. However, the views expressed belong to the author(s) alone and do not necessarily reflect the views of the European Union or the Erasmus+ National Agency -INDIRE. Neither the European Union nor the granting administration can be held responsible for them. Project N°: 2024-1-IT02-KA220-SCH-000249373

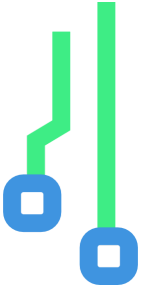
M{AI}L

Conclusion: Empowering future learners with AI

Funded by the European Union. However, the views expressed belong to the author(s) alone and do not necessarily reflect the views of the European Union or the Erasmus+ National Agency -INDIRE. Neither the European Union nor the granting administration can be held responsible for them. Project N°: 2024-1-IT02-KA220-SCH-000249373

Funded by
the European Union

M{AI}L



You have now completed an essential journey into the world of Artificial Intelligence and Machine Learning, specifically exploring how Teachable Machine can become a powerful ally in your classroom. This handbook has guided you through foundational AI/ML concepts, provided step-by-step instructions for creating engaging image, audio, and pose projects, and offered practical strategies for their integration across various subjects.

Embracing these technologies means more than just adopting new tools; it represents a profound opportunity to transform teaching and learning. You are now equipped to demystify complex concepts for your students, spark their curiosity in technology, and foster critical 21st-century skills like problem-solving, creativity, and computational thinking. Preparing students to use these technologies responsibly and effectively becomes a tangible goal within your reach.

The M{AI}L project believes in your pivotal role as educators in shaping the future of education. We encourage you to experiment, innovate, and adapt these strategies to your unique classroom environment. Share your successes, learn from challenges, and contribute to the growing community of teachers leveraging AI for good. This marks not an end, but the exciting beginning of your journey as an AI-empowered educator.

We are confident that your work will inspire a new generation of learners, ready to navigate and contribute to a world increasingly shaped by Artificial Intelligence. Thank you for being a vital part of this transformative initiative.

Funded by
the European Union

Funded by the European Union. However, the views expressed belong to the author(s) alone and do not necessarily reflect the views of the European Union or the Erasmus+ National Agency -INDIRE. Neither the European Union nor the granting administration can be held responsible for them. Project N°: 2024-1-IT02-KA220-SCH-000249373