FAAI:
The Future is in Applied Artificial Intelligence
Erasmus+ project 2022-1-PL01-KA220-HED-000088359

01.09.2022 – 31.08.2024

A4.5 Learning Materials for Training Teachers: WP4

The production of this document has been possible thanks to the support of the ERASMUS+ project: The Future is in Applied Artificial Intelligence (2022-1-PL01-KA220-HED-000088359)

Disclaimer: Co-funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or Fundacja Rozwoju Systemu Edukacji. Neither the European Union nor the granting authority can be held responsible for them.

BY NC ND

Authors

Vasyl MARTSENYUK, Georgi DIMITROV, Dejan RANCIC, Iveta DIRGOVA-LUPTAKOVA, Igor JOVANCEVIC, Marcin BERNAS, Aleksandra KLOS-WITKOWSKA, Tomasz GANCARCZYK

Date
30.04.2023

Places of the development of the result
University of Bielsko-Biala, Bielsko-Biala, Poland
University of Library Studies and Information Technologies, Sofia, Bulgaria
University of Nis, Serbia
University of Ss. Cyril and Methodius in Trnava, Slovakia
University of Montenegro, Montenegro

Summary: This document outlines a comprehensive framework for developing learning materials tailored to training teachers in Applied Artificial Intelligence (AAI). It emphasizes structured methodologies, interactive teaching strategies, and innovative assessment approaches to foster competence-based education.
The content is divided into six main sections. The first section introduces the methodology for training in AAI, outlining objectives, core principles, and a phased framework. These include the foundational phase for theoretical knowledge, the applied learning phase for practical skills, and the pedagogical integration phase to prepare teachers for classroom delivery. Essential tools, resources, and feedback mechanisms are also discussed to enhance the learning process.
Subsequent sections delve into specific instructional strategies, such as preparing lectures in a question-and-answer format to engage learners actively and designing competence-based classes that integrate theoretical and practical elements. Special emphasis is placed on developing use cases and collaborative projects, fostering teamwork and real-world problem-solving skills.
Methodologies for competence examination are highlighted, providing detailed guidelines for structuring foundational and application-level assessments. This includes examples of quizzes, case studies, and team-based projects, along with best practices for evaluation and feedback.
The document also explores how to design learning trajectories, focusing on linear and branching scenarios to cater to diverse learning needs. Activities and resources are recommended to enhance the learning experience, ensuring adaptability and relevance.
The framework prioritizes continuous improvement through feedback and performance analysis, ensuring that the materials remain dynamic and aligned with advancements in AI technologies. By equipping teachers with robust strategies and tools, this document aims to transform AAI education, preparing educators to lead dynamic, engaging, and impactful learning experiences.

Keywords: applied artificial intelligence, competency-based curriculum, tensor-based approach, use-case study, assessment, learning trajectories

Content

I. Introducing the Methodology for Training in Applied Artificial Intelligence (AAI)

A. Objective

The methodology for training in Applied Artificial Intelligence (AAI) aims to empower teachers by fostering a competence-based approach to education. This framework is designed to help educators acquire the necessary knowledge, skills, and tools to teach AAI concepts effectively while also focusing on practical application and critical thinking. The ultimate goal is to prepare teachers to create engaging, impactful, and learner-centered experiences in their classrooms.

B. Key Principles

The foundation of this methodology is built on several guiding principles that prioritize active engagement, real-world relevance, and practical skill-building:

Competence-based education forms the cornerstone of this approach. It emphasizes not just the acquisition of knowledge but also the ability to apply that knowledge effectively in real-world scenarios. Teachers will be guided to focus on outcomes, enabling their students to demonstrate specific competencies in AI.

Another vital element is the integration of question-and-answer sessions. These sessions serve as a platform for interactive learning, where participants can clarify doubts, explore deeper insights, and reflect on key concepts. This interactive dialogue ensures that teachers not only understand theoretical aspects but also feel confident in their ability to apply them in their teaching practices.

Additionally, the use of case studies and learning scenarios is essential

Co-funded by
the European Union

to this methodology. By analyzing real-world examples and working through simulated classroom scenarios, participants gain practical insights into how AAI concepts are applied in diverse contexts. These exercises encourage critical thinking, problem-solving, and creativity while offering hands-on experience.

C. Methodological Framework

The training methodology is organized into three interconnected phases, each designed to build on the previous one to provide a comprehensive learning experience.

1) 1. Foundational Phase

The first phase focuses on establishing a strong foundation in AI concepts. Teachers will delve into the historical evolution of AI, explore its ethical dimensions, and gain a solid understanding of its key technologies and tools. Rather than merely presenting information, this phase encourages critical engagement with foundational topics, laying the groundwork for practical application.

Interactive lectures and multimedia presentations will introduce AI concepts in a dynamic and engaging manner. Teachers will actively participate in discussions and short quizzes designed to test their understanding and promote deeper reflection. This phase also includes initial question-and-answer sessions to address any doubts and set the stage for further exploration.

2) 2. Applied Learning Phase

Building on the foundational knowledge, this phase emphasizes the practical application of AI concepts. Teachers will engage in hands-on exercises, working with AI tools such as Python libraries and platforms like TensorFlow and scikit-learn. These activities are designed to bridge the gap between theory and practice, enabling participants to design and implement simple AI models while gaining confidence in their technical skills.

Case studies play a crucial role in this phase. Teachers will analyze real-world applications of AI in industries such as healthcare, education, and finance. Through collaborative discussions, they will identify key challenges, opportunities, and best practices, drawing valuable lessons that they can incorporate into their own teaching. Moreover, group projects using provided datasets will foster teamwork and problem-solving abilities, offering participants a chance to experiment with AI solutions in a supportive environment.

3) 3. Pedagogical Integration Phase

The final phase focuses on equipping teachers with the tools and strategies necessary to integrate AI concepts into their classrooms effectively. Participants will learn to adapt lessons for various age groups and skill levels, ensuring that their teaching is inclusive and accessible. This phase emphasizes the creation of learning scenarios, enabling teachers to simulate real-world AI challenges and guide their students through structured problem-solving exercises.

Teachers will also develop comprehensive lesson plans and curricula that align with competence-based education principles. These plans will incorporate question-and-answer sessions, case studies, and practical exercises to create an interactive and engaging learning environment. Peer reviews and feedback sessions will further refine their strategies, fostering a collaborative learning community.

D. Tools and Resources

To support teachers in their training, a wide range of tools and resources will be provided. Participants will have access to software platforms such as Jupyter Notebook, Google Colab, and various AI libraries. Detailed teaching aids, including lesson templates, datasets, and interactive simulations, will enable teachers to confidently deliver high-quality AI education. Comprehensive documentation and tutorials will be available to facilitate independent exploration and skill-building.

E. Assessment and Feedback

Assessment and feedback are integral components of this methodology, ensuring that participants achieve meaningful learning outcomes. Continuous assessment will be conducted through weekly quizzes, assignments, and practical exercises, with clear rubrics provided to evaluate performance. Feedback mechanisms will include regular review sessions, allowing teachers to reflect on their progress and address any challenges.

A capstone project will serve as the culmination of the training. Teachers will design and present an AI teaching module, demonstrating their ability to apply the principles of competence-based education. This project will provide a valuable opportunity for participants to showcase their learning while receiving constructive

Co-funded by
the European Union

feedback from their peers and trainers.

F. Conclusion

By following this enhanced methodology, teachers will gain the skills, knowledge, and confidence to effectively teach AAI concepts in their classrooms. The emphasis on competence-based education, interactive question-and-answer sessions, and the integration of case studies and learning scenarios ensures that participants are well-prepared to meet the evolving demands of AI education. This comprehensive approach not only fosters theoretical understanding but also empowers teachers to inspire and engage the next generation of AI learners.

II. Preparing the Lectures in AAI in the Form of Question and Answer Sessions

A. Objective

Lectures in Applied Artificial Intelligence (AAI) designed as Question and Answer (Q&A) sessions aim to provide an engaging, interactive, and learner-focused experience. This approach emphasizes active participation and critical thinking, ensuring that participants not only absorb knowledge but also engage deeply with key concepts. By creating opportunities for discussion and inquiry, Q&A sessions bridge the gap between theoretical understanding and practical application, fostering a more dynamic and collaborative learning environment.

B. Importance of Q&A Sessions in AAI Training

The use of Q&A sessions in AAI training is instrumental in enhancing learning outcomes. By centering the learning process on dialogue and inquiry, participants are encouraged to take an active role in their education. This approach allows instructors to address doubts in real-time, ensuring clarity and deepening understanding. It also nurtures critical thinking, as learners are prompted to analyze concepts, question assumptions, and explore the practical implications of AI technologies.

Moreover, the interactive nature of Q&A sessions caters to diverse learning needs. By tailoring responses to participants' queries, instructors can provide personalized guidance, making the learning process more relevant and impactful. This method also creates a space for collaborative learning, where participants can learn not only from the instructor but also from the questions and perspectives of their peers.

C. Structuring a Q&A-Based Lecture

Designing effective Q&A sessions requires thoughtful preparation and facilitation. The process begins with identifying the key topics to be covered, such as machine learning algorithms, neural networks, or ethical considerations in AI. Instructors should anticipate the types of questions learners might ask and prepare guiding questions to stimulate discussion.

A typical Q&A-based lecture begins with a brief overview of the topic to provide context. This introduction sets the stage for the session, outlining the main points and inviting participants to think critically about the subject matter. An initial question, such as "What are the challenges of implementing AI in healthcare systems?" can serve as an icebreaker, encouraging participants to share their thoughts and questions.

As the session progresses, the instructor facilitates a dynamic exchange of ideas. Responses to participants' questions should be clear and concise, using real-world examples to illustrate key points. For instance, when discussing neural networks, an instructor might explain how they are used in image recognition systems, highlighting their practical applications and limitations. Visual aids, demonstrations, and simulations can enhance these explanations, making abstract concepts more accessible.

Incorporating real-world case studies is a vital aspect of this methodology. Case studies provide a concrete context for learning, enabling participants to see how AI concepts are applied in practice. For example, a discussion on predictive analytics might be grounded in a case study about AI-driven fraud detection in finance. By analyzing such scenarios, participants can explore the benefits and challenges of AI applications, developing a nuanced understanding of the technology.

Another effective strategy is to use learning scenarios that simulate real-world problems. Participants can work through these scenarios collaboratively, applying their knowledge to devise solutions. For instance, a scenario might involve designing an AI system for optimizing supply chain logistics, prompting participants to consider factors such as data quality, algorithm selection, and ethical implications.

D. Facilitating Engagement and Interaction

Successful Q&A sessions rely on creating a supportive and inclusive environment. Instructors should encourage all participants to ask questions and share their perspectives, fostering a sense of community and collaboration. Active listening is crucial, as it demonstrates respect for participants' contributions and helps instructors address their specific needs.

To ensure a balanced discussion, instructors can guide the flow of the session, directing questions to different participants and managing time effectively. Patience and flexibility are essential, as learners may require additional support to articulate their thoughts or grasp complex concepts. By adapting explanations to the audience's background and knowledge level, instructors can make the content more accessible and engaging.

E. Concluding the Session

At the end of the session, the instructor should summarize the main points discussed, reinforcing key takeaways. This summary helps participants consolidate their understanding and provides a clear sense of closure. Any unanswered questions can be addressed in follow-up discussions or through additional resources.

Closing the session with a reflective or forward-looking question encourages participants to continue exploring the topic independently. For example, an instructor might ask, "How do you envision AI transforming your field of expertise in the next decade?" This type of question inspires learners to think critically about the future implications of AI, fostering ongoing curiosity and engagement.

F. Enhancing Q&A Sessions with Tools and Resources

Various tools and resources can support the effectiveness of Q&A sessions. Interactive platforms, such as Mentimeter or Slido, allow participants to submit questions anonymously, ensuring that everyone feels comfortable contributing. AI demonstration tools, such as Google Colab or Jupyter Notebook, can be used to showcase algorithms and models in action, providing a hands-on learning experience. Additionally, access to case study repositories and curated datasets enables instructors to enrich their sessions with real-world examples.

G. Conclusion

Preparing lectures in AAI as Q&A sessions transforms the traditional classroom into a vibrant space for dialogue and discovery. By centering the learning process on inquiry and interaction, this approach empowers participants to actively engage with AI concepts and applications. Through careful preparation, effective facilitation, and the integration of real-world examples, instructors can create meaningful learning experiences that equip participants with the knowledge and skills to navigate the complex world of AI.

III. Preparing the Classes in AAI for Competence-Based Education

A. Introduction

Competence-based education in Applied Artificial Intelligence (AAI) is designed to equip learners with the skills and knowledge necessary to meet the demands of real-world applications. This approach emphasizes the ability to apply theoretical knowledge to practical scenarios, fostering a learning environment where understanding, analysis, and skill-building are prioritized over rote memorization. Preparing classes in AAI for competence-based education requires a thoughtful balance of foundational learning, practical exercises, and critical engagement to ensure that learners can demonstrate their capabilities in tangible ways.

B. Core Features of Competence-Based Education

Competence-based education in AAI is built around several key principles that define its structure and objectives. Central to this approach is the focus on outcomes—learners are evaluated on their ability to perform specific tasks or solve problems rather than merely recalling information. This ensures that the learning process is aligned with real-world demands, making it highly relevant to students' professional aspirations.

Another critical feature is the integration of experiential learning. Through hands-on exercises, case studies, and collaborative projects, learners are immersed in practical scenarios that mimic real-world challenges. For example, students might work on developing a machine learning model to predict customer behavior or optimize inventory management. Such activities foster critical thinking, creativity, and problem-solving skills, enabling students to approach AI-related tasks with confidence.

Additionally, competence-based education emphasizes continuous feedback and reflection. Instructors play an active role in guiding learners, providing constructive feedback, and helping them refine their understanding and skills. Regular assessments, such as project evaluations or practical demonstrations, allow learners to track their progress and identify areas for improvement.

C. Designing Competence-Based AAI Classes

Preparing competence-based AAI classes begins with defining clear learning objectives that align with the desired outcomes. For instance, a class on natural language processing (NLP) might aim to enable students to build and evaluate sentiment analysis models. These objectives serve as a roadmap for both instructors and learners, ensuring that the class remains focused and goal-oriented.

The next step involves curating content that balances theoretical and practical components. While foundational concepts like neural networks and data preprocessing are essential, the emphasis should be on their application. Instructors can use interactive lectures, multimedia resources, and real-world examples to introduce topics, followed by practical exercises that allow students to apply what they've learned.

Case studies and learning scenarios play a crucial role in competence-based AAI classes. These tools provide learners with a realistic context for applying their knowledge, encouraging them to analyze, design, and implement AI solutions. For example, a case study on autonomous vehicles might challenge students to develop algorithms for object detection and decision-making, highlighting the ethical and technical considerations involved.

Collaborative projects are another effective strategy for fostering competence-based learning. By working in teams, students can tackle complex problems, exchange ideas, and develop a deeper understanding of AI concepts. For instance, a group project might involve designing a recommendation system for an e-commerce platform, requiring students to consider factors such as user preferences, data quality, and algorithm selection.

D. Supporting Tools and Resources

To facilitate competence-based education in AAI, instructors can leverage a variety of tools and resources. Platforms like Google Colab and Jupyter Notebook provide a practical environment for coding and experimentation, while AI libraries such as TensorFlow and PyTorch offer powerful tools for implementing machine learning models. Additionally, access to curated datasets and case study repositories can enrich the learning experience, providing students with diverse opportunities to explore and apply AI concepts.

Instructors can also use assessment tools to evaluate learners' competencies effectively. Rubrics and performance criteria should be aligned with the learning objectives, ensuring that assessments measure not just knowledge but also the ability to apply it. For instance, a practical exam might require students to develop a working chatbot using natural language processing techniques, demonstrating their understanding of the underlying algorithms and their ability to implement them.

E. Conclusion

Preparing classes in AAI for competence-based education involves a holistic approach that combines theoretical understanding with practical application. By focusing on outcomes, integrating experiential learning, and providing continuous feedback, this methodology ensures that learners are well-equipped to meet the demands of the AI industry. Through carefully designed classes that emphasize real-world relevance, instructors can create a dynamic and impactful learning experience that empowers students to excel in the field of Applied Artificial Intelligence.

IV. Preparing Use Cases in AAI for Competence-Based Education (Case Study, Team Working)

A. Introduction

Use cases in Applied Artificial Intelligence (AAI) provide an essential bridge between theoretical knowledge and practical application. By focusing on real-world scenarios, they enable learners to explore the complexities and challenges of AI technologies in action. Preparing use cases specifically for competence-based education involves designing activities that foster problem-solving, critical thinking, and collaboration, making them a powerful tool for developing the skills needed in modern AI applications. This approach not only deepens learners' understanding of AI concepts but also equips them with the practical abilities to tackle real-world challenges.

B. Importance of Use Cases in Competence-Based Education

The integration of use cases into AAI education serves multiple purposes. First, it contextualizes learning by demonstrating how AI concepts are applied in various industries, from healthcare and finance to transportation and retail. This real-world relevance enhances learners' engagement and motivation, as they can see the tangible impact of their work.

Second, use cases encourage active learning. By analyzing and solving practical problems, learners move beyond passive absorption of information to actively engaging with the material. This approach nurtures critical thinking, as students must evaluate different approaches, identify potential challenges, and propose effective solutions.

Finally, use cases promote teamwork and collaboration. Many AI projects require interdisciplinary collaboration, making team-based learning scenarios particularly valuable. By working together on use cases, learners develop not only technical skills but also communication, coordination, and leadership abilities, which are critical for success in the AI workforce.

C. Designing Use Cases for Competence-Based Education

When preparing use cases for AAI training, it is essential to align them with the principles of competence-based education. This involves:

1) 1. Identifying Relevant Scenarios

Use cases should be grounded in real-world challenges that are relevant to learners' interests and career goals. For example, a use case on predictive maintenance could explore how AI is used to monitor industrial equipment, while another on fraud detection might examine algorithms for identifying suspicious transactions in financial systems. The scenarios should be complex enough to challenge learners but also feasible within the scope of their current knowledge and skills.

2) 2. Structuring the Activity

Each use case should follow a clear structure, guiding learners through the problem-solving process. This typically includes:

- **Problem Description:** Providing a detailed explanation of the scenario, including its context, objectives, and constraints.
- **Data and Tools:** Supplying the necessary datasets, software, and tools for analysis. For instance, learners might use Python, TensorFlow, or scikit-learn to develop machine learning models.
- **Tasks and Questions:** Outlining specific tasks or questions to guide learners' exploration. For example, a use case on sentiment analysis might ask students to preprocess text data, build a classification model, and evaluate its performance.
- **Expected Outcomes:** Defining the desired outcomes, such as a functioning prototype, a detailed report, or a presentation of findings.

3) 3. Encouraging Teamwork

To foster collaboration, use cases should be designed as group activities. Each team member can take on a specific role, such as data analyst, algorithm designer, or project manager, ensuring that everyone contributes to the project's success. Instructors should provide guidance on effective teamwork strategies, such as setting clear goals, dividing responsibilities, and communicating effectively.

4) 4. Incorporating Reflection and Feedback

After completing a use case, learners should have the opportunity to reflect on their experiences and receive constructive feedback. This process helps them identify strengths and areas for improvement, reinforcing their learning and preparing them for future challenges.

D. Examples of Use Cases

- **1. Autonomous Vehicles**

In this use case, learners design an AI system for autonomous vehicles. Tasks might include developing algorithms for object detection using computer vision, simulating decision-making processes for navigation, and addressing ethical considerations related to safety and accountability.

- **2. Healthcare Diagnostics**

Learners explore how AI is used to improve healthcare outcomes. For example, they might analyze medical imaging data to detect anomalies, such as tumors, using convolutional neural networks (CNNs). This use case emphasizes both technical skills and ethical issues, such as patient privacy and bias in training data.

- **3. E-Commerce Recommendations**

This use case focuses on building a recommendation system for an online retail platform. Learners work with customer data to develop collaborative filtering or content-based algorithms, considering factors like scalability, personalization, and user satisfaction.

E. Facilitating Use Case Implementation

To ensure the success of use case-based learning, instructors should provide comprehensive support throughout the process. This includes:

- **Preparation:** Supplying detailed instructions, resources, and guidance to help learners understand the objectives and requirements of each use case.
- **Monitoring:** Actively engaging with learners during the activity, answering questions, and offering assistance as needed.
- **Evaluation:** Assessing learners' performance based on predefined criteria, such as the quality of their solutions, their ability to work collaboratively, and their understanding of the underlying concepts.

F. Conclusion

Preparing use cases in AAI for competence-based education is a powerful way to bridge the gap between theory and practice. By focusing on real-world scenarios, these activities help learners develop the technical, analytical, and collaborative skills needed to excel in the field of AI. Through thoughtful design, effective facilitation, and meaningful reflection, use cases transform AAI education into a dynamic and impactful learning experience that prepares students for the challenges and opportunities of the AI-driven future.

V. Preparing Methodologies for the Competence Examination (Quizzes, etc.)

Competence-based assessments in Applied Artificial Intelligence (AAI) go beyond traditional testing by measuring both theoretical knowledge and practical skills in real-world contexts. Effective methodologies for these examinations ensure learners are prepared not just for academic challenges but for professional environments requiring innovation, critical thinking, and technical expertise. Below, we delve into detailed methodologies for creating such assessments, highlighting best practices, tools, and tips for maximizing their effectiveness.

A. Structuring Competence Assessments

1) 1. Foundational Level: Building Knowledge and Decision-Making Skills

This level focuses on ensuring learners grasp essential theoretical concepts, terminologies, and methodologies in AAI. Learners are also expected to understand the fundamental logic behind selecting appropriate tools, algorithms, or techniques for specific scenarios.

Key Methodologies for Foundational Level Assessments:

- **Quizzes and Knowledge-Based Tasks:** These are designed to ensure learners have a clear grasp of basic concepts and their relevance in practical scenarios.
    - **Multiple-Choice Questions (MCQs):**
        - *Example:* “Which of the following algorithms is most suitable for image classification tasks? A) Decision Trees, B) Convolutional Neural Networks (CNN), C) K-Means Clustering.”
        - **Elaboration:** MCQs test precise knowledge and decision-making skills. To make them more effective, include real-world problems like “Identify the best AI approach to classify medical images for detecting tumors.”
        - **Good Practice:** Integrate question-level feedback. For instance, if a student selects the wrong answer, the system provides an explanation, reinforcing learning. Tools like Google Forms or Moodle allow automated

Co-funded by
the European Union

feedback integration.

        - **Tip:** Gradually increase complexity. Begin with basic recall questions and progress to application-oriented questions that require deeper thinking.

    - **Short-Answer Questions:**
        - *Example:* "Define overfitting in machine learning and list two strategies to address it."
        - **Elaboration:** These questions encourage learners to write concise, precise answers, demonstrating conceptual clarity. Short-answer questions are particularly useful for technical definitions, summarizing processes, or explaining relationships between concepts.
        - **Good Practice:** Provide model answers for self-assessment. Learners can compare their responses with well-drafted answers to identify gaps.

- **Scenario-Based Decision Tasks:**
    - **Description:** Scenarios challenge learners to think critically and apply knowledge in context.
        - *Example:* "A company wants to predict its monthly revenue based on historical sales data. Which type of machine learning approach—supervised, unsupervised, or reinforcement—would you recommend? Justify your answer."
        - **Good Practice:** Ensure scenarios are diverse, relatable, and reflective of real-world challenges. Offer datasets or supplementary information when needed to make tasks realistic.
        - **Tip:** Encourage learners to document their decision-making process, enabling instructors to assess their reasoning alongside the final

answer.

2) 2. Application Level: Demonstrating Practical Skills

This level evaluates learners' abilities to translate theoretical knowledge into actionable solutions. Learners must showcase proficiency in coding, problem-solving, and interpreting results. These assessments mirror professional tasks like data analysis, model building, and decision-making.

Key Activities for Application Assessments:

1. **Script Execution and Analysis:**
    - **Task Description:** Provide learners with partially written scripts, datasets, or model frameworks. Their task is to execute the script, interpret the output, and suggest improvements.
        - *Example:* "Using the provided dataset of customer reviews, run a sentiment analysis script. Analyze the accuracy and propose modifications to improve the model's performance."
    - **Good Practice:** Balance structure and flexibility. For beginners, include comments in the script explaining each section. For advanced learners, provide minimal guidance to encourage independent problem-solving.
    - **Tip:** Use error-prone scripts deliberately to evaluate debugging skills. For instance, introduce a logical error in a machine learning pipeline and ask learners to identify and fix it.
2. **Case Studies:**
    - **Description:** Present learners with complex, real-world scenarios that require end-to-end problem-solving. Case studies integrate data analysis, modeling, interpretation, and business insights.
        - *Example:* "Develop a predictive model for a healthcare provider to anticipate patient readmission rates. Include the following steps:
            - Data cleaning and preprocessing.
            - Model selection and training.

Co-funded by the European Union

        - Evaluation using accuracy, precision, and recall metrics."
    - **Good Practice:** Offer datasets with real-world nuances like missing values, outliers, and imbalanced classes. This prepares learners for professional challenges.
    - **Tip:** Encourage a written report that details their process, decisions, and results. Include prompts for self-reflection, such as "What challenges did you encounter, and how did you address them?"

3. **Team-Based Projects:**
    - **Description:** Collaboration is critical in AAI projects. Team-based assignments simulate real-world teamwork, requiring learners to share tasks, solve problems, and present results collectively.
        - *Example:* "Your team is tasked with building a recommendation system for an online bookstore. Divide responsibilities among team members (data preparation, model development, evaluation) and create a cohesive final presentation."
        - **Good Practice:** Assign roles explicitly (e.g., data engineer, algorithm developer, project manager) to ensure accountability and skill diversity.
        - **Tip:** Use collaborative platforms like GitHub or Google Drive for version control and teamwork. Include peer evaluation to assess individual contributions.

B. Tools and Resources for Competence Assessments

Leveraging the right tools ensures assessments are interactive, efficient, and aligned with real-world practices. Here are some recommendations:

- **Coding Environments:** Platforms like Jupyter Notebook or Google Colab allow learners to code in a cloud-based environment without worrying about local setup issues.
    - **Tip:** Provide starter templates for learners unfamiliar with coding. For instance, pre-load datasets or include comments that explain complex functions.
- **AI Frameworks and Libraries:** Use TensorFlow, PyTorch, and Scikit-learn for coding exercises.
    - **Example:** Provide a pre-built model in TensorFlow and ask learners to modify the hyperparameters to improve accuracy.
    - **Good Practice:** Focus on intuitive libraries like Scikit-learn for beginners and introduce more complex frameworks like PyTorch gradually.
- **Automated Feedback Tools:** Tools like Gradescope or Codio automate code evaluation and provide instant feedback.
    - **Tip:** Set criteria for feedback, such as code efficiency, readability, and output accuracy.
- **Visualization Tools:** Use Tableau, Matplotlib, or Power BI to integrate data visualization into assessments.
    - *Example:* "Using Matplotlib, create a bar chart comparing the accuracy of three models you trained."

C. Best Practices for Effective AAI Assessments

To ensure assessments are impactful and aligned with learning objectives, consider these practices:

1. **Incorporate Real-World Relevance:**
    - Ensure problems reflect industry needs.
    - *Example:* Use a dataset from Kaggle, such as "Titanic Survival Prediction," to teach classification problems.
2. **Encourage Iterative Learning:**
    - Allow learners to attempt tasks multiple times.
    - *Good Practice:* Provide hints or partial credit for identifying errors in failed attempts.
3. **Use Gamification:**

Co-funded by the European Union

- Introduce leaderboards, rewards, and badges.
- *Example:* "Award a badge for completing a debugging challenge within 10 minutes."

4. **Foster Reflection:**
   - Include reflective questions post-assessment, such as "What would you do differently if given the same task again?"
   - *Good Practice:* Ask learners to write a journal summarizing their key takeaways after completing each assessment.

D. Example Competence Assessment Plan

Objective: Assess learners' theoretical knowledge, decision-making, and practical skills in AI.
Weight Distribution:

- Knowledge Quiz: 20%
- Coding Exercise: 30%
- Case Study Presentation: 50%

Steps:

1. Conduct a 15-question quiz covering basic concepts, such as supervised learning algorithms and evaluation metrics.
2. Provide learners with a partially complete Python script for model training. Their task is to complete it and explain the results.
3. Assign a group project requiring learners to build an AI-based predictive system for real-world use (e.g., weather prediction or inventory management).

VI. How to Develop Learning Trajectories?

Designing effective learning trajectories in Applied Artificial Intelligence (AAI) involves creating a structured yet dynamic pathway that transforms students into active participants in their educational process. Rather than passively receiving information, students are guided through a progressive learning journey that emphasizes exploration, critical thinking, and hands-on problem-solving. This approach provides a robust foundation for developing both theoretical understanding and practical expertise in AI technologies.

A. The Core Principles of Learning Trajectories

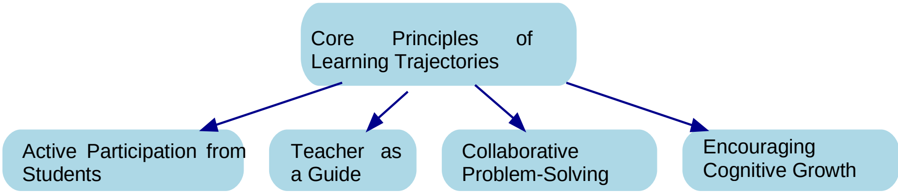


Figure 1 Core principles of learning trajectories

1) Active Participation from Students

In AAI, learning trajectories emphasize that students take an active role in their education. Instead of simply being given answers, they explore problems, develop hypotheses, and implement solutions. For example, rather than receiving step-by-step instructions on building a neural network, students may be challenged to design and train a model for a specific dataset, encouraging them to experiment and iterate.

Collaborative Problem-Solving: Team-based activities further enhance this approach by replicating real-world AI workflows. Students may tackle tasks such as predictive modeling or dataset analysis in groups, with each member contributing their expertise to a larger collaborative effort. Through these experiences, they learn to communicate effectively, share responsibilities, and integrate diverse perspectives.

2) Teacher as a Guide, Not a Lecturer

Traditional models of teaching often rely on the instructor as the primary source of information. In contrast, effective learning trajectories require teachers to act as facilitators who guide students through their learning journey. Instead of providing direct answers, they prompt exploration by posing open-ended questions such as, *"What are the ethical considerations of using biased training data?"* or *"How would you approach optimizing this model for better accuracy?"

Encouraging Cognitive Growth: Teachers also foster deeper understanding by challenging students to evaluate their processes and outcomes. This reflective practice not only reinforces technical skills but also nurtures adaptability and critical thinking.

B. Essential Steps in Designing Learning Trajectories

- **1. Define Clear and Purposeful Objectives**

An effective trajectory starts with clearly defined goals that outline what students should know and be able to do by the end of the course. These goals must address both theoretical concepts and practical competencies.

Practical Objective Examples:

- *Knowledge Goals:* Understand the principles behind machine learning algorithms like decision trees and neural networks.
- *Application Goals:* Build and validate machine learning models using Python libraries such as TensorFlow or Scikit-learn.

Best Practices: Use frameworks like Bloom's Taxonomy to create objectives that progress from foundational understanding to advanced application. For instance, students may begin by explaining key AI concepts before progressing to tasks like optimizing machine learning workflows for real-world use cases.

- **2. Structure the Learning Pathway into Phases**

Effective learning trajectories divide the educational process into distinct phases, each targeting specific milestones.

Phases of Learning:

1. **Introduction to Fundamentals:** Focus on theoretical concepts such as statistics, data preprocessing, and AI ethics.
2. **Skill Development:** Introduce practical tasks like data exploration, visualization, and algorithm implementation.
3. **Advanced Applications:** Address complex topics such as deep learning and domain-specific AI (e.g., healthcare or finance).
4. **Integration and Reflection:** Encourage students to synthesize their knowledge in capstone projects or internships.

C. Linear and Branching Scenarios in Learning Trajectories

Scenarios provide the backbone of learning trajectories, offering structured or adaptive pathways for students to apply their knowledge. Both linear and branching approaches play critical roles.

- **Linear Scenarios: Structured and Sequential**

Linear scenarios follow a step-by-step progression, ideal for teaching foundational workflows.

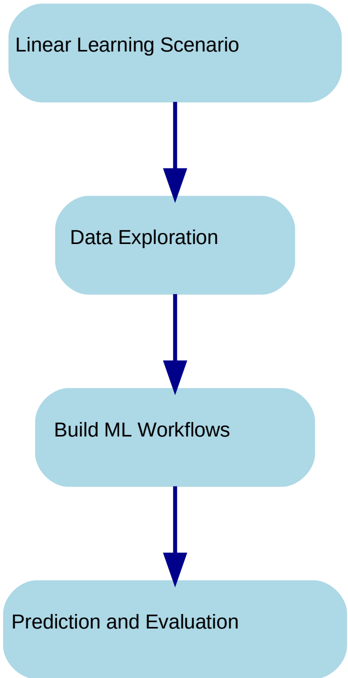


Figure 2 Linear scenario

Example: Linear Scenario (Lecture 1)

- **Step 1: Data Exploration for Classic Machine Learning:** Students start by exploring datasets using external libraries (e.g., Pandas) to understand their structure and key features.
- **Step 2: Building ML Workflows:** They then design workflows for preprocessing and training classic machine learning models.
- **Step 3: Prediction and Evaluation:** Finally, they use trained models to make predictions and evaluate their performance using metrics like accuracy and precision.

This approach ensures that students master each stage of the AI pipeline, building confidence and competence as they progress.

- **Branching Scenarios: Adaptive and Decision-Oriented**

Branching scenarios allow students to explore multiple pathways, making decisions that shape their learning experience.

Example: Ethical Dilemmas in AI

- **Scenario:** Students encounter a biased hiring algorithm and must decide between two actions:
    - *Option 1:* Collect new, unbiased training data.
    - *Option 2:* Modify the existing algorithm to adjust for fairness.
- **Outcome:**
    - *Option 1* leads students to focus on data quality and preprocessing challenges.
    - *Option 2* involves re-engineering the algorithm and evaluating trade-offs like accuracy versus fairness.

Branching scenarios are especially effective for encouraging critical thinking and teaching the nuances of real-world decision-making.

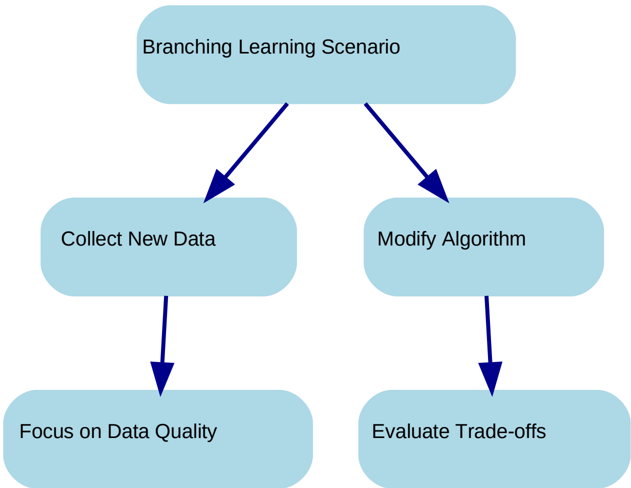
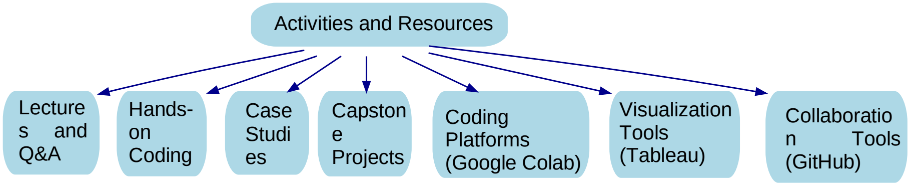


Figure 3 Branching scenario

D. Enhancing Learning Trajectories with Activities and Resources

Co-funded by the European Union

Learning trajectories thrive when supplemented by varied activities that cater to different learning styles.



Sample Activities:

- **Lectures with Interactive Q&A:** Present theoretical concepts and encourage students to ask questions that deepen their understanding.
- **Hands-On Coding:** Assign tasks where students implement machine learning algorithms, debug errors, and analyze results.
- **Case Studies:** Challenge students with real-world problems such as fraud detection or supply chain optimization, requiring them to propose comprehensive AI solutions.
- **Capstone Projects:** Encourage students to develop end-to-end AI applications, such as chatbots or recommendation systems, that integrate multiple competencies.

Recommended Tools and Platforms:

- **Coding Environments:** Google Colab and Jupyter Notebook for hands-on exercises.
- **Visualization Tools:** Tableau or Matplotlib for creating data insights.
- **Collaborative Platforms:** GitHub for teamwork and version control.

E. Continuous Improvement of Learning Trajectories

Learning trajectories must evolve based on feedback, performance analysis, and advancements in AI technologies.

Improvement Strategies:

- Gather regular feedback from students to identify challenges and adjust content accordingly.
- Analyze assessment data to pinpoint areas where students struggle.
- Integrate emerging topics like explainable AI or federated learning to ensure the curriculum remains cutting-edge.

F. Conclusion

Learning trajectories in AAI represent a shift from traditional teaching to a more active, student-centered model. By blending structured and adaptive approaches, emphasizing critical thinking, and incorporating diverse activities, these trajectories empower students to master both the theory and application of AI. Teachers act as guides, fostering independent inquiry and equipping learners with the skills needed to excel in a rapidly evolving field. Through continuous refinement, these trajectories remain dynamic and relevant, preparing students for meaningful contributions in AI-driven industries.

VII. ANNEX

Please see the link to the presentations

https://faai.ath.edu.pl/?p=913

VIII. REFERENCES

[1] Faai job hub – the future is in applied artificial intelligence 2022-1-pl01ka220-hed-000088359. https://faai.ath.edu.pl/. (Accessed on 07/04/2023).

[2] Chaomei Chen, Fidelia Ibekwe-SanJuan, and Jianhua Hou. The structure and dynamics of cocitation clusters: A multiple-perspective cocitation analysis. *Journal of the American Society for Information Science and Technology*, 61(7):1386–1409, March 2010.

[3] Fabiano Bini, Andrada Pica, Laura Azzimonti, Alessandro Giusti, Lorenzo Ruinelli, Franco Marinozzi, and Pierpaolo Trimboli. Artificial intelligence in thyroid field—a comprehensive review. *Cancers*, 13(19):4740, September 2021.

[4] Farzad V. Farahani, Krzysztof Fiok, Behshad Lahijanian, Waldemar Karwowski, and Pamela K. Douglas. Explainable AI: A review of applications to neuroimaging data. *Frontiers in Neuroscience*, 16, December 2022.

[5] Onur Dogan, Sanju Tiwari, M. A. Jabbar, and Shankru Guggari. A systematic review on AI/ML approaches against COVID-19 outbreak. *Complex &amp Intelligent Systems*, 7(5):2655–2678, July 2021.

[6] Vijay Kumar, Dilbag Singh, Manjit Kaur, and Robertas Damaševičius. Overview of current state of research on the application of artificial intelligence techniques for COVID-19. *PeerJ Computer Science*, 7:e564, May 2021.

[7] Zhuoqing Chang, Shubo Liu, Xingxing Xiong, Zhaohui Cai, and Guoqing Tu. A survey of recent advances in edge-computing-powered artificial intelligence of things. *IEEE Internet of Things Journal*, 8(18):13849– 13875, September 2021.

[8] Muddasar Naeem, Syed Tahir Hussain Rizvi, and Antonio Coronato. A gentle introduction to reinforcement learning and its application in different fields. *IEEE Access*, 8:209320–209344, 2020.

[9] Rohan Gupta, Devesh Srivastava, Mehar Sahu, Swati Tiwari, Rashmi K. Ambasta, and Pravir Kumar.

Co-funded by the European Union

Artificial intelligence to deep learning: machine intelligence approach for drug discovery. *Molecular Diversity*, 25(3):1315–1360, April 2021.

[10] Jingyi Zhao and Guifang Fu. Artificial intelligence-based family health education public service system. *Frontiers in Psychology*, 13, May 2022.

[11] Bui Hoang Bac, Hoang Nguyen, Nguyen Thi Thanh Thao, Vo Thi Hanh, Le Thi Duyen, Nguyen Tien Dung, Nguyen Khac Du, and Nguyen Huu Hiep. Estimating heavy metals absorption efficiency in an aqueous solution using nanotube-type halloysite from weathered pegmatites and a novel harris hawks optimization-based multiple layers perceptron neural network. *Engineering with Computers*, 38(S5):4257–4272, July 2021.

[12] Yann LeCun, Yoshua Bengio, and Geoffrey Hinton. Deep learning. *Nature*, 521(7553):436–444, May 2015.

[13] Karen Simonyan and Andrew Zisserman. Very deep convolutional networks for large-scale image recognition, 2014.

[14] Volodymyr Mnih, Koray Kavukcuoglu, David Silver, Andrei A. Rusu, Joel Veness, Marc G. Bellemare, Alex Graves, Martin Riedmiller, Andreas K. Fidjeland, Georg Ostrovski, Stig Petersen, Charles Beattie, Amir Sadik, Ioannis Antonoglou, Helen King, Dharshan Kumaran, Daan Wierstra, Shane Legg, and Demis Hassabis. Human-level control through deep reinforcement learning. *Nature*, 518(7540):529–533, February 2015.

[15] Ian Goodfellow, Yoshua Bengio, and Aaron Courville. *Deep learning*. MIT press, 2016.

[16] Jürgen Schmidhuber. Deep learning in neural networks: An overview. *Neural Networks*, 61:85–117, January 2015.

[17] Olga Russakovsky, Jia Deng, Hao Su, Jonathan Krause, Sanjeev Satheesh, Sean Ma, Zhiheng Huang, Andrej Karpathy, Aditya Khosla, Michael Bernstein, Alexander C. Berg, and Li Fei-Fei. ImageNet large scale visual recognition challenge. *International Journal of Computer Vision*, 115(3):211–252, April 2015.

[18] Alex Krizhevsky, Ilya Sutskever, and Geoffrey E. Hinton. ImageNet classification with deep convolutional neural networks. *Communications of the ACM*, 60(6):84–90, May 2017.

[19] David Silver, Aja Huang, Chris J. Maddison, Arthur Guez, Laurent Sifre, George van den Driessche, Julian Schrittwieser, Ioannis Antonoglou, Veda Panneershelvam, Marc Lanctot, Sander Dieleman, Dominik Grewe, John Nham, Nal Kalchbrenner, Ilya Sutskever, Timothy Lillicrap, Madeleine Leach, Koray Kavukcuoglu, Thore Graepel, and Demis Hassabis. Mastering the game of go with deep neural networks and tree search. *Nature*, 529(7587):484–489, January 2016.

[20] Joelle Elmaleh and Venky Shankararaman. Improving student learning in an introductory programming course using flipped classroom and competency framework. In *2017 IEEE Global Engineering Education Conference (EDUCON)*, pages 49–55, 2017.

[21] Manus Ross, Corey A. Graves, John W. Campbell, and Jung H. Kim. Using support vector machines to classify student attentiveness for the development of personalized learning systems. In *2013 12th International Conference on Machine Learning and Applications*, volume 1, pages 325– 328, 2013.

[22] Shah Neyamat Ullah. Examples of authentic assessments in engineering education. In *2020 IEEE Global Engineering Education Conference (EDUCON)*, pages 894–897, 2020.

[23] Jose Louie Mark Z. Ano, Geoffrey A. Solano, John Arthur P. Hernan, and Ronalyn Grace Francisco. Warp: A workflow-aware instructional platform for competency-based learning. In *2019 10th International Conference on Information, Intelligence, Systems and Applications (IISA)*, pages 1–4, 2019.

[24] Arman Raj, Vandana Sharma, Seema Rani, Tanya Singh, Ankit Kumar Shanu, and Ahmed Alkhayyat. Demystifying and analysing metaverse towards education 4.0. In *2023 3rd International Conference on Innovative Practices in Technology and Management (ICIPTM)*, pages 1–6, 2023.

[25] Promoting competency-based learning | sertifier. https://sertifier.com/blog/promoting-competency-based-learning/. (Accessed on 06/30/2023).

[26] Michael Schumm, Saskia Joseph, Irmgard Schroll-Decker, Michael Niemetz, and Jürgen Mottok. Required competences in software engineering: Pair programming as an instrument for facilitating life-long learning. In *2012 15th International Conference on Interactive Collaborative Learning (ICL)*, pages 1–5, 2012.

[27] Davy Tsz Kit Ng, Min Lee, Roy Jun Yi Tan, Xiao Hu, J. Stephen Downie, and Samuel Kai Wah Chu. A review of AI teaching and learning from 2000 to 2020. *Education and Information Technologies*, 28(7):8445–8501, December 2022.

[28] Thomas K. F. Chiu, Helen Meng, Ching-Sing Chai, Irwin King, Savio Wong, and Yeung Yam. Creation and evaluation of a pretertiary artificial intelligence (AI) curriculum. *IEEE Transactions on Education*, 65(1):30– 39, February 2022.

[29] Becky Allen, Andrew Stephen McGough, and Marie Devlin. Toward a framework for teaching artificial intelligence to a higher education audience. *ACM Transactions on Computing Education*, 22(2):1–29, November 2021.

[30] Computing competencies for undergraduate data science curricula. https://www.acm.org/binaries/content/assets/education/curricula-recommendations/dstf$_c$*cdsc*2021.*pdf* .(*Accessedon*07/05/2023).

[31] Matthew L. Jockers. *Text Analysis with R for Students of Literature*. Springer International Publishing, 2014.

[32] Cristian Felix, Steven Franconeri, and Enrico Bertini. Taking word clouds apart: An empirical investigation of the design space for keyword summaries. *IEEE Transactions on Visualization and Computer Graphics*, 24(1):657–666, January 2018.

[33] Stamatios Giannoulakis and Nicolas Tsapatsoulis. Topic identification via human interpretation of word clouds: The case of instagram hashtags. In *IFIP Advances in Information and Communication Technology*, pages 283–294. Springer International Publishing, 2021.

[34] Shaher H. Zyoud and Daniela Fuchs-Hanusch. A bibliometric-based survey on ahp and topsis techniques. *Expert Systems with Applications*, 78:158–181, 2017.

[35] M. Raissi, P. Perdikaris, and G.E. Karniadakis. Physics-informed neural networks: A deep learning framework for solving forward and inverse problems involving nonlinear partial differential equations. *Journal of Computational Physics*, 378:686–707, February 2019.

[36] Geoffrey Hinton, Li Deng, Dong Yu, George Dahl, Abdel rahman Mohamed, Navdeep Jaitly, Andrew Senior, Vincent Vanhoucke, Patrick Nguyen, Tara Sainath, and Brian Kingsbury. Deep neural networks for acoustic modeling in speech recognition: The shared views of four research groups. *IEEE Signal Processing Magazine*, 29(6):82–97, November 2012.