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A Model for School Subject "AI Proficiency" for Advanced students in Secondary TVET School: Conceptual Framework and Content with Practical Exemplary Curriculum

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ABSTRACT: The article proposes a subject model for special preparation for professional education and training for classes in the professional field Computer Science and Technology, as a continuation of the subject „*Introduction to AI: General education*" for TVET secondary schools in Bulgaria, proposed by the author in a previous published article. The model is balanced, with an emphasis on active learning with a synergistic and holistic creative approach, where over 80% of the time the student is involved in an active (individual or collective) activity: researching materials, drawing up models, discussions and debates, SWOT analyses, as well as project-based tasks of greater or lesser volume, problem cases. The topics are considered not only in their strict technical context, but also holistically-synergistically: ethics in the matter of AI, strategies for regulations, future perspectives and benefits, personal interests. The curriculum aims to provide vocational high school students with a comprehensive understanding of AI, covering fundamental concepts, practical applications, advanced technologies, ethical considerations and future trends in the field, through a combination of theoretical learning, practical projects, creative activity and discussions, develop critical thinking skills and will prepare for further study or careers in AI-related fields.

KEYWORDS: Artificial Intelligence, Algorithm, Model, Discussion, Learning Subject, Learning Project.

ARTIFICIAL INTELLIGENCE IN THE DISCOURSE OF SECONDARY EDUCATION

Artificial Intelligence (AI) is increasingly permeating various aspects of our lives, revolutionizing industries and reshaping societal norms. In healthcare, AI-powered systems are demonstrating remarkable capabilities, outperforming human experts in certain tasks. For instance, AI algorithms have been shown to outperform dermatologists in detecting skin cancer (*Shnurenko, 2022*). Similarly, AI-driven voice analysis is being used to identify potential health risks, such as heart attacks, during emergency calls (*Shnurenko, 2022*).

In the realm of cybersecurity, AI-powered tools are being employed to detect and respond to cyber threats. Troy Hunt, a prominent cybersecurity expert, has developed an AI-based application that tracks the origins of data breaches. In the education sector, AI is being used to enhance teaching and learning. Thanks to AI, the top manager of Microsoft, Troy Hunt, has created an application that searches hundreds of recently hacked pages and traces the origin of hacker attacks (*Ibid.: 27*).

On the grounds of schools in the Chinese city of Hangzhou, near Shanghai, AI cameras have been installed that track children's faces and check their emotional state and level of attention during class, which is a powerful tool for evaluating student performance. to motivate for proactive future activity, as well as to control entry and exit of students and teachers in schools and security, providing valuable insights for educators (*Ibid.: 24*).

In practice, AI has become "*in part of our collective mind, is a kind of extension in it; fighting with AI is like crazy, we are fighting with ourselves*" (*Ibid.: 37*).

Noam Chomsky's assertion that educators must continually adapt to technological advancements underscores the importance of ongoing learning and skill development, "*if you teach today what you taught five years ago, either the discipline is dead, or you are*" (*Chomsky, 1993*). The rapid evolution of AI has necessitated a shift in educational paradigms, emphasizing the acquisition of digital literacy and critical thinking skills. As AI continues to evolve, it is increasingly clear that students need to be equipped with the knowledge and skills to navigate this technological landscape. The development of superintelligent AI systems in the future highlights the urgent need for comprehensive AI education in secondary schools. By fostering a deep understanding of AI principles

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and applications, we can empower students to become responsible digital citizens and contribute to the ethical development of AI technologies.

Kordon (*2023:29*) presents a genealogical review of AI, illustrating its evolutionary development as a spiral progression (see **Figure 1**.). While current AI systems exhibit limited intelligence, future societal demands may necessitate the development of superintelligent systems that surpass human intellectual capabilities. This prospect underscores the critical importance of equipping students with a strong foundation in science and technology education. Given the rapid advancements in AI, TVET schools should prioritize equipping future generations with the necessary competencies to thrive in an AI-driven world. To address this need, AI curriculum focused on cultivating AI literacy should be created. This curriculum emphasizes three core competencies: *AI Knowledge, AI Skills,* and *AI Attitude*. By focusing on these areas, we aim to prepare students to effectively engage with AI technologies and understand their societal implications. Recent research underscores the significance of integrating (AI) into educational curricula across various levels. For high school students, a two-year AI subject centered on embedded intelligence and smartphone applications has been proposed (*Bellas et al., 2022*). At the elementary level, a curriculum emphasizing AI literacy through the development of knowledge, skills, and attitudes has been suggested (*Kim et al., 2021; Cai et al., 2023*). For early childhood education, a framework incorporating AI literacy and utilizing social robots as learning companions has been recommended (*Su & Zhong, 2022*). In the field of medical education, the necessity of integrating AI into existing curricula has been identified, focusing on understanding AI tools, engineering frameworks, and ethical implications (*Grunhut et al., 2021*). These studies collectively highlight the importance of preparing students at all educational levels for an AI-driven future, emphasizing the need for practical, age-appropriate approaches to AI education that foster both technical understanding and critical thinking skills.

Niewint-Gori (*2023*) examins thourougly the specific ways ai can enhance student learning in educational settings. AI can provide valuable insights into student performance, enabling targeted instruction and early intervention when needed. For instance, formative assessment systems can evaluate student learning and provide useful data to teachers, which can be integrated into personalized learning platforms. This minimizes loss of instructional time while offering valuable feedback on student progress. Additionally, AI technologies can create an integrated learning experience where they work together, communicating with teachers and school organizations to improve the teaching and learning process. By focusing on accessibility and inclusivity, AI can help bridge gaps for diverse learners, including those with disabilities and historically underserved populations, thereby promoting equity in education.

Challenges of Integrating AI in Education 4 of the primary challenges is the fragmented nature of the current learning ecosystem, where multiple AI technologies operate independently, leading to inefficiencies and missed opportunities for collaboration. Furthermore, there are concerns regarding algorithmic bias, as algorithms can reflect the values and biases of their creators, potentially perpetuating existing inequalities in educational outcomes. Educators also face difficulties in adapting their pedagogy to the complexities introduced by AI technologies, and policies often lag behind the rapid pace of technological advancements. Addressing the digital divide and ensuring that all students have access to AI tools is crucial to prevent exacerbating existing inequities in education.

Table 1. Core topics on AI and Education: summary

Core Topics	*Description*
AI's Impact on Education	Enhance student learning through personalized lesson plans and targeted instruction. Formative assessment systems provide valuable insights into student performance.
Challenges of AI Integration	Fragmented learning ecosystem leads to inefficiencies and missed collaborative opportunities. Algorithmic bias can perpetuate existing inequalities in educational outcomes.
Need for AI Literacy	Significant need for AI literacy among educators and students to effectively engage with AI tools. Education for AI should include understanding its fundamentals and applications in various fields.
Promoting Inclusivity and Equity	AI has the potential to bridge gaps for diverse learners but must be designed with accessibility in mind. Addressing the digital divide is essential to ensure all students benefit from AI advancements.
Future Directions	Importance of aligning new technological paradigms with democratic values and inclusive practices. Calls for investment in infrastructure and digital literacy to support effective AI integration in education.

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A number of studies over the past two years have analyzed some of the functions of AI in relation to education. Authors such as (*Chan & Tsi , 2023*) share that AI provides methods for more effective learning and offers more effective models and procedures for student experience. Research by scientists from Elon University leads to the conclusion that AI can effectively help determine the level of students after the completion of a given course and help plan for the next one (*Committee , 2023*).

It is important to distinguish between education ***in*** AI, ***for*** AI, ***about*** AI and education ***with*** AI.

- ***Education in AI*** focuses on teaching students the foundational aspects of artificial intelligence, including its definition, history, and significance. It covers essential concepts such as machine learning, deep learning, and neural networks, enabling students to grasp the underlying principles of AI technologies. This area also emphasizes the ethical and social implications of AI, discussing issues like algorithmic bias and the importance of responsible AI use. Additionally, it includes data literacy, where students learn about data analysis, visualization, and the various types and sources of data.
- ***Education with AI*** refers to the integration of AI technologies into the teaching and learning process. This includes personalized learning, where AI tailors educational experiences to meet individual student needs and learning styles, and adaptive learning technologies that adjust content based on performance. It also involves using AI for assessment and feedback, providing real-time insights into student progress and automating grading. Furthermore, AI can streamline administrative functions within educational institutions, enhancing efficiency in tasks like scheduling and resource allocation. Collaborative learning is supported through AI-driven platforms, and engagement is increased by incorporating gamification and interactive learning experiences.
- ***Education about AI*** emphasizes raising awareness and understanding of AI among students and educators. This includes exploring the fundamentals of AI, its applications across various fields, and the ethical considerations surrounding its use. It aims to equip learners with the knowledge necessary to critically engage with AI technologies and understand their societal impacts.
- ***Education for AI*** focuses on preparing students for careers in the AI field. This involves developing specific skills and competencies related to AI, such as programming, data science, and machine learning. It aims to provide students with the practical knowledge and experience needed to work in AI-related roles, ensuring they are equipped to contribute to the development and application of AI technologies in various industries.

Conclusively education *in* AI is about understanding and developing AI technologies. Education *with* AI focuses on using AI to enhance educational practices. Education *about* AI aims to raise awareness and understanding of AI's implications and applications, and education *for* AI prepares students for careers in the AI field, see ***Table 1.*** Together, these areas are essential for equipping learners for a future where AI plays a significant role in various domains.

Table 2. AI different functions in skills creation in the context of TVET: summary

Aspect of Education	*Description*	*Skills Development*
Education in AI	Teaches foundational AI concepts, including machine learning and ethical implications, while promoting data literacy.	Understanding algorithms, basic programming, and ethical reasoning.
Education with AI	Integrates AI technologies into learning, enabling personalized education, adaptive assessments, and streamlined administrative tasks.	Skills in using AI tools for teaching, data analysis, and enhancing student engagement.
Education about AI	Raises awareness of AI fundamentals, applications, and ethical considerations, equipping learners to engage critically with AI.	Critical thinking, ethical analysis, and awareness of AI's societal impacts.
Education for AI	Prepares students for AI careers by developing skills in programming, data science, and machine learning.	Proficiency in programming languages, data analysis, and machine learning techniques.

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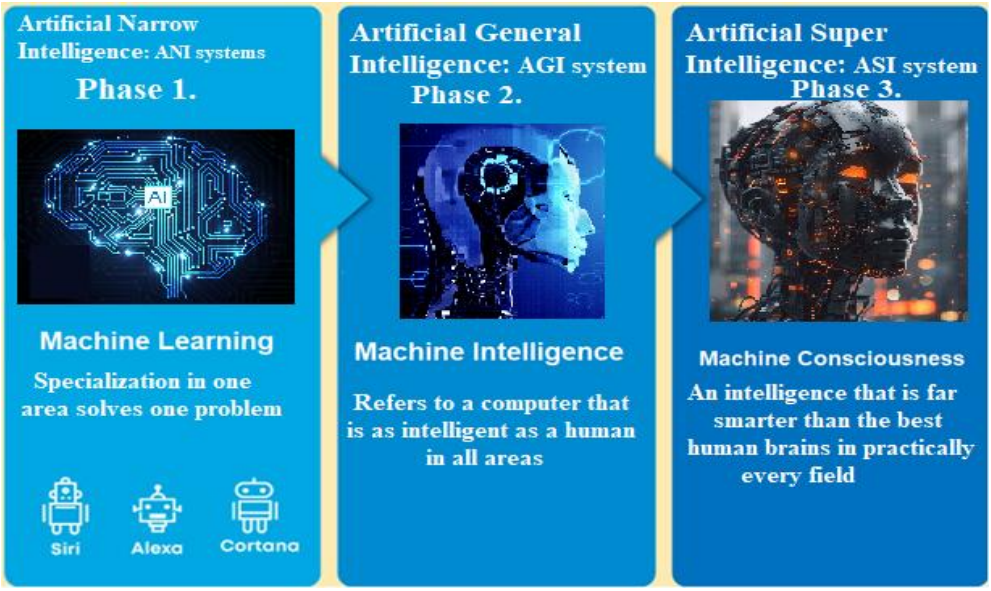

Figure 1. The three evolutionary phases of artificial intelligence by Kordon (2023).
Author's source

A model of the structure and content of AI as a subject for Advanced students in TVET

Designing a comprehensive (AI) curriculum for students involves a combination of theoretical knowledge, practical skill development (see ***table 2.***), and real-world application.

The present article aims to descriptively create a model for training in a subject in secondary vocational education for students ***vocational*** *direction* ***4.6*** *(as well as* ***5.2, 5.3)*** , as a continuation of the subject " ***Introduction*** *to* ***AI*** " proposed by the author in a previous article *(* Vasilev, I., Model for studying the subject " AI") based on the conceptual and functional characteristics of AI.

For the in-depth study of AI, the author suggests in other articles, division into **two subjects** studied in the second high school level of secondary education in TVET:

1. Introduction to AI (for general secondary education).

2. Programming AI in TVET (for professional and vocational education).

And ***3. AI Proficiency in TVET*** (for professional and vocational education).

The subject *"Introduction to AI"* is not intended to be profiled, but is suitable for all types of secondary school classes and covers thematic cores such as *: basic knowledge and definition of AI, basic methods of algorithmic data processing, the functions of AI and -deployed AI applications.* The article offers a thematic and time distribution and learning content for this subject.

The subject "*AI Programming"* and the subjects in it are aimed at profiling and professional preparation for the specialties "Computer Technician", "System Programming", "Cybersecurity" and all from professional field ***4.3, 5.2, 5.3***, covering knowledge of: *predicate calculus and declarative languages introduction to AI programming analysis of list concepts stack, queue, graph, trees search methods AI algorithmics* **.**

The subject Programming of Artificial I ntelligence can be completed variably with:

1. forming a complete **portfolio** of each student
2. drawing up an individual **Capstone project .**

Capstone project [1] e o a major project in education and symbolizes the culmination of the student 's "learning journey", representing the pinnacle of their learning experience.

The Capstone project is designed to provide an opportunity to explore in depth something that interests the student personally , and the approaches can be different :

- "*Capstone research"* option, this can be a topic that the student has always wanted to learn more about and deepen knowledge by interviewing experts and personal analyses, on a topic in the subject area.

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- *comparative analysis* , to reveal and compare personal positions and "truths" with someone else's, also presented by the environment, relatives, scientists, teachers ;
- *the experimental design* - they could design their own experimental test, their hypothesis, collect data and share results;
- it can be in *the form of a cause* that is internally motivated and related to the subject, and for which the student would like to volunteer his time;
- it can be in *the form of professional experience* and presence in the given professional environment. Such an option has a double effect, because the student will be able to determine whether a given career is suitable for him.

Examplar content framework of "AI Proficiency" for TVET students for High School in the fields of Electrical Science, Electronics, and Computer Science and Technology.

The *core* components of this proposed subject focus on:

- **Knowledge Systems**: Exploring the structures and frameworks through which knowledge is organized, stored, and utilized.
- **Methods of Knowledge Representation**: Examining techniques for modeling and encoding information, enabling machines to interpret, reason, and apply data effectively. This includes symbolic representations, ontologies, and semantic networks.
- **Machine Learning**: Investigating algorithms and statistical models that enable computers to learn from and make predictions based on data, with applications in pattern recognition, decision-making, and automation.

*Thematic units in the subject "AI for Advanced in TVET" - **54** hours **(3** hours per week).*

❖ **YEAR 1*:* In-Depth Analysis of AI Algorithms. Knowledge Representation and Reasoning. Knowledge Discovery and Machine Learning.**

➢ ***TERM 1 :*** *Types of AI Algorithms (11 weeks)***.** *Types of Knowledge Representation and Reasoning* ***(KRR)*** (4 weeks from Term1 and continues 9 weeks in Term 2).

Topic: *Basic terms and concepts of AI Algorithms:* (1 week)

- *Definitions*: problem world, close/open world; Relation, transition operator, reduction operator spatial decomposition, AND/OR tree.

Topic: *In-depth Search algorithm***:** see ***Table 3.*** (2-4 week)

Table 3. Search algorithms: a summary

Algorithm Category	***Algorithms***
Blind Search	Depth-First Search (DFS), Breadth-First Search (BFS), Iterative Deepening (ID), Bi-directional Search (BiS), Branch and Bound (B&B)
Heuristic Search	Hill Climbing (HC), Enforced Hill Climbing (EHS), Simulated Annealing (SA), Tabu Search (TS), Beam Search (BS), Best-First Search (BestFS), A* Search, Iterative Deepening A* (IDA*)
Adversary Search	Minimax (MiniMax), Alpha-Beta (AB)

Topic: *In-depth Genetic algorithm***.** (6-8 week)

1. Genetic algorithms.
- Search space, solution space in GA.
- Usage of GA
2. Ant Colony Optimization (ACO).
3. Particle Swarm Optimization (PSO).

Possible student activities (in class and/or for homework assignment):

Practical Tasks: week 1-4

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- **Implement DFS and BFS:**
  - Create a maze-solving problem and implement DFS and BFS to find the shortest path.
  - Analyze the performance of both algorithms in terms of time and space complexity.
- **Implement Iterative Deepening:**
  - Modify the DFS algorithm to implement iterative deepening search.
  - Compare the performance of iterative deepening with DFS and BFS.
- **Implement Bi-directional Search:**
  - Implement a bidirectional search algorithm to solve a specific problem.
  - Analyze the performance gains of bidirectional search compared to unidirectional search.
- **Implement Branch and Bound:**
  - Implement a branch and bound algorithm to solve optimization problems, such as the knapsack problem.
  - Compare the performance of branch and bound with other search algorithms.

In-depth Genetic Algorithms (6-8 weeks)

Week 1-2:

- **Introduction to Genetic Algorithms:**
  - Explain the basic concepts of genetic algorithms, including chromosomes, genes, fitness function, selection, crossover, and mutation.
  - Discuss the advantages and disadvantages of genetic algorithms compared to other optimization techniques.

Week 3-4:

Practical Implementation:

- **Implement a Simple Genetic Algorithm:**
  - Create a genetic algorithm to solve a simple optimization problem, such as the one-max problem.
  - Experiment with different genetic operators and parameters to optimize the performance of the algorithm.
- **Implement a Genetic Algorithm for a Real-World Problem:**
  - Apply genetic algorithms to solve real-world problems, such as scheduling, routing, or machine learning.
  - Analyze the results and compare them with other optimization techniques.

Week 5-6:

- **Advanced Topics:**
  - Explore advanced genetic algorithm techniques, such as parallel genetic algorithms, hybrid genetic algorithms, and evolutionary strategies.
  - Discuss the challenges and limitations of genetic algorithms.

Week 7-8:

- **Project Work:**
  - Students work on individual or group projects to apply genetic algorithms to solve a real-world problem.
  - Presenting the projects and discussing their findings.

Topic: *In-depth Knowledge Representation and Reasoning see* ***Figure 2*** . (9-12 week)

Week 1-2: Foundational Concepts

- **Introduction to Knowledge Representation and Reasoning:**
  - Define key terms: *knowledge, information, data, facts, ontologies, concepts, syntax, semantics.*
  - Discuss the distinction between *tacit* and *explicit* knowledge.
  - Explore the dimensionality of knowledge and its implications for representation.
- **Knowledge Representation Techniques:**
  - Textual Knowledge Representation:
    - Analyze the limitations and advantages of representing knowledge in text format.
    - Discuss the role of natural language processing (NLP) in understanding and representing textual knowledge.

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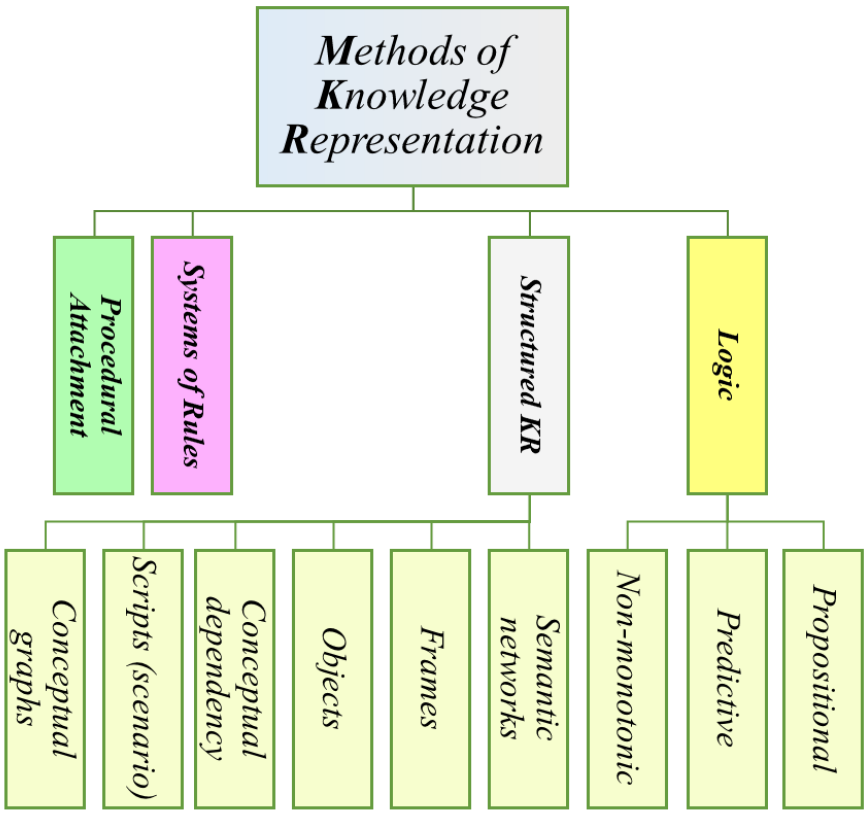

Figure 2. Methods of Knowledge Representation.
Author's source

- Ontological Knowledge Representation:
  - Introduce ontologies as a formal representation of knowledge.
  - Explore ontology languages (e.g., OWL) and their use in knowledge representation.
- Rule-Based Knowledge Representation:
  - Discuss the use of rules and logic to represent knowledge and reason about it.
  - Explore forward and backward chaining inference techniques.
- Frame-Based Knowledge Representation:
  - Introduce frames and slots as a structured approach to representing knowledge.
  - Discuss the advantages and limitations of frame-based systems.
- Semantic Networks and Conceptual Graphs:
  - Explore graphical representations of knowledge, including semantic networks and conceptual graphs.
  - Discuss the use of these representations for knowledge reasoning and inference.

Week 3-4: Knowledge Representation and Reasoning in AI Systems

- **Knowledge Representation in AI Systems:**
  - Discuss the role of knowledge representation in various AI applications, such as expert systems, natural language processing, and machine learning.
  - Analyze the challenges and opportunities in knowledge representation.
- **Knowledge-Based Systems:**
  - Explore the architecture and components of knowledge-based systems.
  - Implement a simple knowledge-based system using a rule-based approach.

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- Semantic Web and Linked Data:
  - Discuss the semantic web and its potential for knowledge sharing and integration.
  - Explore the use of linked data for representing and querying knowledge.

Week 5-6: Reasoning and Inference Techniques

- **Deductive Reasoning:**
  - Introduce formal logic and its application to reasoning.
  - Explore the use of inference rules and proof procedures.
- **Inductive Reasoning:**
  - Discuss the principles of inductive reasoning and its role in machine learning.
  - Explore techniques for learning patterns from data.
- **Abductive Reasoning:**
  - Introduce abductive reasoning and its application in problem-solving and diagnosis.
  - Discuss the challenges of abductive reasoning and its limitations.

Week 7-8: Evaluation of Knowledge Representation Methods

- **Evaluation Criteria:**
  - Discuss the key criteria for evaluating knowledge representation methods, including representational adequacy, inferential adequacy, inferential efficiency, and acquisition efficiency.
  - Analyze the strengths and weaknesses of different knowledge representation techniques based on these criteria.
- **Case Studies:**
  - Explore real-world examples of knowledge representation and reasoning in AI applications.
  - Analyze the effectiveness of different techniques in specific domains.

Week 9-12: Advanced Topics (Optional)

- **Probabilistic Reasoning:**
  - Introduce Bayesian networks and probabilistic logic.
  - Discuss the application of probabilistic reasoning in uncertain domains.
- **Machine Learning and Knowledge Representation:**
  - Explore the intersection of machine learning and knowledge representation.
  - Discuss the use of machine learning techniques to learn and reason with knowledge.
- **Knowledge Graph:**
  - Introduce the concept of knowledge graphs and their applications.
  - Discuss the challenges and opportunities of building and maintaining large-scale knowledge graphs.

Possible student activities (in class and/or for homework assignment):

- **Task 1: Knowledge Representation Exercise**
  - representing a simple domain, such as a family tree or a university course catalog, using different knowledge representation techniques (e.g., semantic networks, ontologies, rules).
- **Task 2: Knowledge Acquisition and Engineering**
  - work on a knowledge acquisition task, extracting knowledge from text or expert interviews and representing it in a formal knowledge base.

Week 3-4: Knowledge Representation and Reasoning in AI Systems

- **Task 1: Building a Simple Expert System**
  - building a simple expert system using a rule-based approach to diagnose a specific problem (e.g., car trouble, medical diagnosis).
- **Task 2: Implementing a Semantic Web Application**
  - creating a simple semantic web application using a knowledge graph to represent information about a specific domain (e.g., movies, books, or scientific concepts).

Week 5-6: Reasoning and Inference Techniques

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- **Task 1: Logical Reasoning Exercises**
  - practicing deductive, inductive, and abductive reasoning by solving logic puzzles and problems.
  - analyzing real-world examples of reasoning, such as legal arguments or medical diagnoses.
- **Task 2: Implementing a Reasoning System**
  - implementing a simple reasoning system using a logic programming language (e.g., Prolog) or a rule-based system.

Week 7-8: Evaluation of Knowledge Representation Methods

- **Task 1: Comparative Analysis**
  - compare different knowledge representation techniques (e.g., semantic networks, ontologies, rules) based on their strengths and weaknesses.
  - analyzing the suitability of different techniques for specific domains and applications.
- **Task 2: Knowledge Base Design**
  - designing a knowledge base for a specific domain, considering factors such as scalability, maintainability, and query efficiency.

Week 9-12: Advanced Topics (Optional)

- **Task 1: Probabilistic Reasoning**
  - Implementing a Bayesian network to model uncertain information and make probabilistic inferences.
- **Task 2: Machine Learning and Knowledge Representation**
  - Using machine learning techniques to extract knowledge from data and integrate it into a knowledge base.
- ***Task 3: Knowledge Graph Construction***
  - Building a knowledge graph using a knowledge graph framework (e.g., RDF, OWL) and populate it with data from various sources.

➢ ***TERM 2:*** *Machine Learning (ML) see* ***Figure 3.*** *(18 weeks)*

Topic: *In-depth Machine Learning. (10 weeks)*

1. Definition and idea of Machine Learning (ML)

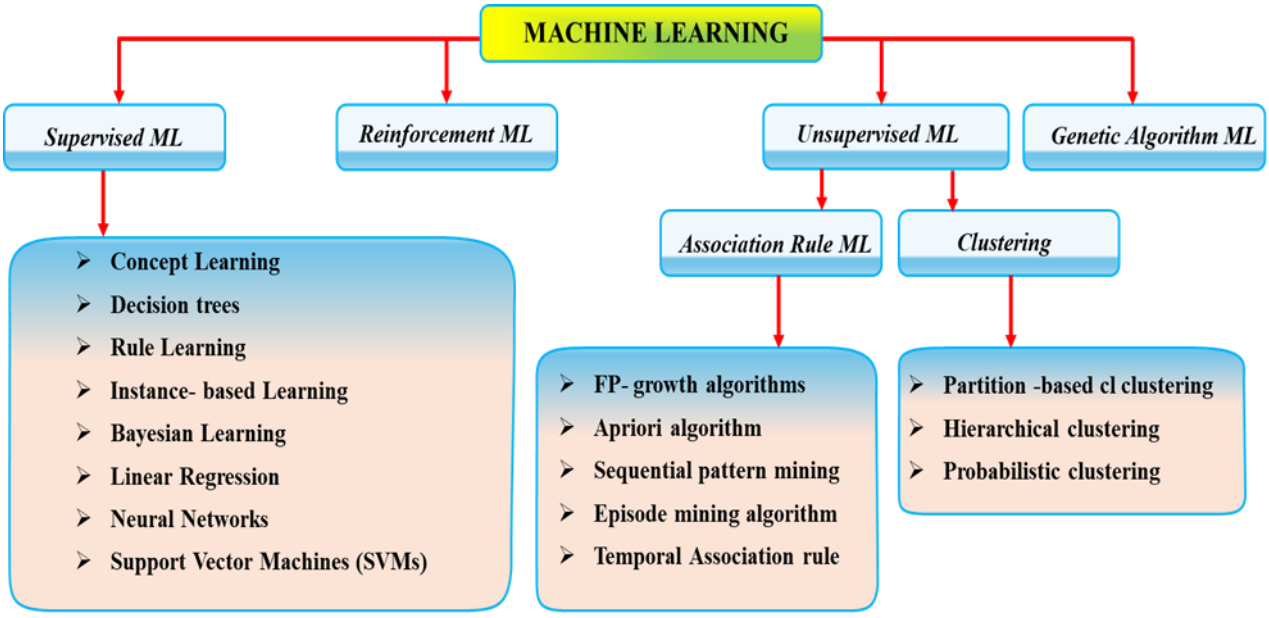

Figure 3. Machine Learning: summary. Author's source

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2. Methods of Machine Learning: divisions, basic steps and examples of each branch of ML.
3. Algorithms of ML.
    - Algorithm for Backpropagation [*needed knowledge of Derivatives In Maths*]
    - Algorithm for Gradient Descent
    - Algorithm for Transfer Learning
4. Machine Teaching (MT) and Types of MT.
    - Machine Teaching with Decision Trees
    - Machine Teaching with Evolutionary Computation
    - Machine Teach with Intelligent Agents (Chatbots)

Possible student activities (in class and/or for homework assignment):

Week 1-2

- Task 1: Implement a simple linear regression model to predict house prices based on square footage.
- Task 2: Build a logistic regression model to classify whether a given email is spam or not.

Week 3-4: Supervised Learning

- Task 1: Implement a support vector machine (SVM) to classify handwritten digits from the MNIST dataset.
- Task 2: Train a decision tree and a random forest model on a classification dataset.
- Task 3: Experiment with different hyperparameters for SVM, decision trees, and random forests to improve performance.

Week 5-6: Unsupervised Learning

- Task 1: Apply K-means clustering to group similar data points in a dataset.
- Task 2: Use hierarchical clustering to create a dendrogram and identify clusters in a dataset.
- Task 3: Implement PCA to reduce the dimensionality of a high-dimensional dataset.

Week 7-8: Deep Learning

- Task 1: Build a simple neural network to classify images from the MNIST dataset.
- Task 2: Implement a convolutional neural network (CNN) for image classification tasks.
- Task 3: Train a recurrent neural network (RNN) for text classification or time series prediction.

Week 9-10: Machine Teaching and AI Ethics

- Task 1: Design a simple machine teaching scenario, where a human teacher teaches a machine learning model to classify images.
- Task 2: Discuss the ethical implications of AI, such as bias, fairness, and privacy.
- Task 3: Research and present on a specific AI ethics issue, such as autonomous vehicles or facial recognition.

❖ **YEAR 2: Knowledge Systems (KS), Agent Systems. Aplication of KS.**

➢ ***TERM 1:*** *Definition of Knowledge Systems (KS), Types of KS. Application of KS (18 weeks)*

Topic: *In-depth Knowledge System.*

1. Definition Knowledge System, Expert System, Intelligent System. Difference between system and conventional computer program
2. Characteristics of Knowledge System
    - Explanation and justification of reasoning
    - Capacity speed of response
    - Handling uncertainty or incomplete knowledge
3. Architecture of Knowledge System.
    - Blackboard architecture with independent cooperating expert
    - Knowledge base: static base dynamic base, working memory
    - Inference engine: interpreter, Scheduler, conflict of Rules
    - Consistency check and effectors

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- Validation verification and transparency

4. Usage of Knowledge Systems. Examples and Cases. See ***Figure 4.***

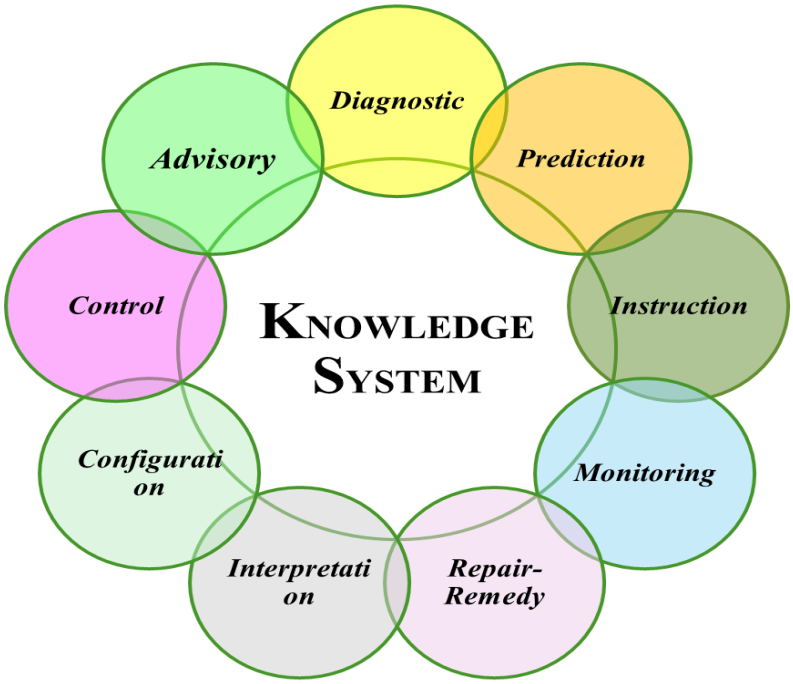

Figure 4. Knowledge System Applications. Author's source

5. Sophisticated Reasoning (SR). Types of SR
   - Model-based reasoning: mathematical, stochastic and casual models.
   - Qualitative reasoning.
   - Case-based reasoning: case library, case retrieval, case adaptation, case verification
   - The **KATE** model [Knowledge-based Autonomous Test Engineer]
6. Knowledge Systems Applications
   - Heuristic Classification: Data Abstraction, Heuristic Match, Solution Refinement, Definition of Abstraction, Qualitative Abstraction, Generalization Abstraction.
   - Configuration of Knowledge.
7. Knowledge Engineering (KE). Model of Configuration of KE.
   - Result-oriented, Document-oriented, Rapid prototyping KE.
   - Knowledge Acquisition, Knowledge Analysis and Modelling, Knowledge Elicitation.
8. Mistakes in KE:
   - Compiled [Blind] Knowledge
   - Wishful Thinking
   - Biasing
   - Inexpert Expert,
   - Indisposed Expert

Possible student activities (in class and/or for homework assignment):

Week 1-2: Introduction to Knowledge Systems

- Task 1: Define knowledge, information, and data, and explain the differences between them.

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- Task 2: Research and discuss different types of knowledge systems, such as expert systems, knowledge-based systems, and intelligent agents.
- Task 3: Analyze real-world examples of knowledge systems (e.g., medical diagnosis systems, financial advisors) and identify their components.

Week 3-4: Knowledge Representation and Reasoning

- Task 1: Implement a simple rule-based expert system using a programming language like Python or Prolog.
- Task 2: Create a semantic network or ontology to represent a specific domain (e.g., biology, computer science).
- Task 3: Experiment with different knowledge representation techniques (e.g., frames, scripts, semantic networks) and evaluate their effectiveness.

Week 5-6: Advanced Knowledge Representation and Reasoning

- Task 1: Explore advanced reasoning techniques, such as case-based reasoning and probabilistic reasoning.
- Task 2: Implement a case-based reasoning system to solve a specific problem.
- Task 3: Analyze the limitations of traditional knowledge-based systems and discuss the potential of hybrid approaches.

Week 7-8: Knowledge Engineering and Acquisition

- Task 1: Conduct knowledge elicitation interviews with domain experts.
- Task 2: Analyze and model the acquired knowledge using appropriate knowledge representation techniques.
- Task 3: Evaluate the quality of the knowledge base and identify potential errors or inconsistencies.

Week 9-10: Applications of Knowledge Systems

- Task 1: Develop a knowledge-based system for a specific application, such as a tutoring system or a decision support system.
- Task 2: Analyze the ethical implications of knowledge-based systems and discuss potential biases.
- Task 3: Evaluate the performance of knowledge-based systems using appropriate metrics.

➢ ***TERM 2:*** *Design and Application of Agent Systems*. (13 weeks)

Topic: *In-depth Agent Systems.*

1. Basic terms: *Agent Oriented Program Multi-Agent System, System Distributed AI, Methods of Interconnection*
2. Types of Agents:
   [1] Internal State Agents
   [2] Logic-Based Agents
   [3] Belief-Based Agents
   [4] Intentionality Agents
   [5] Active Agents
   [6] Hybrid Agents
   [7] Mobile Agents
3. Communication types and Communication Protocol
4. Protocol of communication Languages: *KQML , FIPA ACL*
5. Protocols of Interaction
6. Semantic Web, ontologies, domain, RDF, datatype /object-type properties.

Possible student activities (in class and/or for homework assignment):

Week 1-2: Introduction to Agent-Based Systems

- Task 1: Implement a simple reflex agent that can navigate a grid world.
- Task 2: Design and implement a model-based agent that can plan its actions based on a world model.

Week 3-4: Agent Communication and Interaction

- Task 1: Implement a multi-agent system where agents communicate using a simple language (e.g., FIPA-ACL).
- Task 2: Design and implement a negotiation protocol for agents to bargain over resources or tasks.

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Week 5-6: Knowledge Representation and Reasoning in Agents

- Task 1: Create a knowledge base for a specific domain (e.g., medical diagnosis, fault diagnosis) and implement a rule-based reasoning system.
- Task 2: Implement an agent that uses a belief-desire-intention (BDI) architecture to make *decisions.*

Week 7-8: Multi-Agent Systems

- Task 1: Design and implement a multi-agent system to simulate a traffic scenario.
- Task 2: Create a multi-agent system to solve a resource allocation problem.

Week 9-10: Semantic Web and Agent-Based Systems

- Task 1: Use a semantic web toolkit (e.g., RDF, OWL) to create a knowledge graph for a specific domain.
- Task 2: Implement an agent that can query and reason over a semantic web knowledge base.

Week 11-12: Advanced Topics

- Task 1: Implement a mobile agent system that can migrate between different hosts.
- Task 2: Design and implement an agent-based simulation to study social phenomena (e.g., crowd behavior, opinion formation).

CONCLUSION

The article presents a well-structured educational framework designed to prepare vocational high school students for the rapidly evolving landscape of Artificial Intelligence. Recognizing the critical importance of AI in various sectors, the model emphasizes a balanced approach that combines theoretical knowledge with practical skill development and real-world applications. The curriculum is structured to promote active learning, where over 80% of classroom time is dedicated to engaging activities such as research, model creation, discussions, and project-based tasks. This interactive methodology not only enhances students' understanding of fundamental AI concepts but also encourages them to explore ethical considerations, regulatory strategies, and future implications of AI technologies. By implanting critical thinking and problem-solving skills, the curriculum aims to empower students to become responsible digital citizens who can navigate the complexities of AI and contribute positively to its ethical development. The model addresses the urgent need for comprehensive AI education, ensuring that future generations are equipped with the competencies necessary to thrive in an AI-driven world and to engage meaningfully with the societal implications of these technologies.

NOTES:

1. https :// www . now . edu / blog / what - is - a - capstone - project /#:~: text = Capstone %20 projects %20 come %20 in %20 all , for %20 work %20 in %20 their %20 field .

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