

**Survey on Artificial Intelligence in Education**

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E-Mail Id: [arun.tigadi@gmail.com](mailto:arun.tigadi@gmail.com)**Abstract**

The field of Artificial Intelligence in education has undergone significant developments over last years. We analyze papers of journal of AI in education to identify foci and typical scenarios that occupy the field of AI in education. Artificial Intelligence (AI) already plays a major role in our daily life. Sound knowledge about AI and the principles of computer science will be of vast importance for future careers in science and engineering. Looking towards the near future, jobs will largely be related to AI. In this context literacy in AI and computer science will become as important as classic literacy (reading/writing). By using an analogy with this process we developed a novel AI education concept aiming at fostering AI literacy. The concept comprises modules for different age groups on different educational levels. Fundamental AI/computer science topics addressed in each module are, amongst others, problem solving by search, sorting, graphs and data structures. We developed, conducted and evaluated four proof-of-concepts modules focusing on kindergarten/primary school as well as middle school, high school and university. Preliminary results of the pilot implementations indicate that the proposed AI education concept aiming at fostering AI literacy works.

**Keywords:** Artificial Intelligence in education, AI literacy, educational robotics, literacy, kindergarten, primary/secondary education, undergraduate education.

**Introduction**

Artificial Intelligence plays an important role in our daily life. People use different devices, applications and services which are based on the principles of AI. Considering the current technological development, sound knowledge about AI and the principles of computer science will be of vast importance for future careers in science and engineering. Looking towards future, jobs will largely be related to AI as it will be the basis of the products where our future wealth will be built. In order to develop AI literacy it is crucial as well to familiarize people with the underlying concepts of AI and computer science as early as possible [1].

The development of classic literacy we developed AI education concept for different age groups on different educational levels aiming at fostering AI literacy. Developing reading/writing literacy begins during pre-school, continues through primary, middle and high school and extends through university. In kindergarten children are introduced to letters in a playful way, followed by a more methodological approach in primary school. Each sub-sequent level of education fortifies already learnt knowledge, introduces new topics and explores certain topics in depth [4].

The modules of our AI education concept build on one another, each module covering basic topics in a greater detail as well as introducing new/advanced topics. For instance, modules for kindergarten/primary school introduce fundamental AI/computer science topics like graphs and data structures, sorting, problem solving by search, while subsequent modules also cover advanced AI/computer science topics like automata, intelligent agents, planning and machine learning. Based on this AI education concept we developed four proof-of-concepts modules focusing on kindergarten, middle school, high school and university. All four modules have been conducted and evaluated.

## Methodology

In the near future profound knowledge about AI and computer science will be the basis for careers in science and engineering since more and more AI based products and services will emerge [1].

The following stages regarding AI literacy development, Building awareness and playful exploring AI topics (kindergarten, primary school).Experimenting and familiarizing with the theory behind certain AI topics and working independently on solving a problem (middle school).Fostering core AI topics and getting familiar with advanced AI topics; independently acquire and apply knowledge (high school).Becoming fluent in AI; applying problem solving methods on a higher abstraction level; fostering fundamental understanding of AI topics (university) [5].

## AI Education Concept

These sections provide an overview of contents, structure and goals of each module.

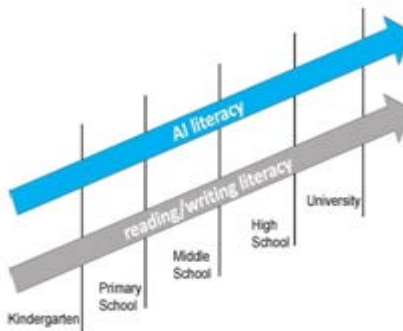


Fig.1. Development of AI literacy in analogy with classic literacy (reading/writing) on different educational levels

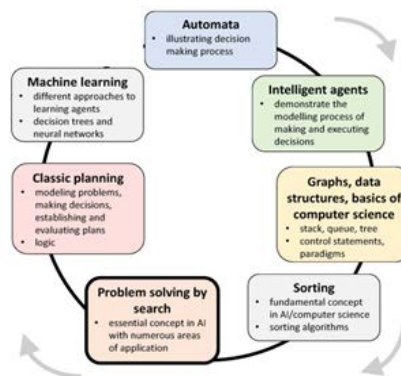


Fig.2. Topics of AI literacy

### **A. Kindergarten and Primary School**

The research in the area of classic literacy shows that, it is essential to start to learn basic reading/writing skills at an early [2], [3]. This module is to introduce kindergarten and primary school children (aged between four and eight years) to the core AI/computer science topics in a playful way by breaking down complex contents in an age-appropriate fashion.

Following an overview of AI/computer science topics covered in several hands-on units, Graphs and data structures (e.g. programming a Bee- Bot to traverse a graph in order to find a way out of a maze). Sorting algorithms (e.g. sorting LEGO bricks according to the bubble sort algorithm). Problem solving by search (e.g. children have to traverse a graph from the root to a certain node to demonstrate blind search, children wear a special helmet where they can only see the next edge of the graph).

### **B. Middle School**

Looking at reading/writing literacy in later years of education, the focus of teaching shifts more towards supporting children to develop independent reasoning and comprehension skills. Applying this knowledge to our AI literacy approach, in this module school students (aged between eleven and thirteen years) take a first look at the theory behind certain AI topics and apply this knowledge afterwards in a practical group project encouraging them to analyze and work independently on solving a specific problem [5] .

The module fosters core AI topics, in particular graphs and data structures as well as problem solving by search. Furthermore, it introduces the concept of intelligent agents. After completing this module school students should have a basic idea of fundamental data structures and search algorithms and understand the connection between those AI techniques and common AI applications.

Basically the module is structured as follows: Raising a guiding research question (e.g. what does AI have to do with graphs, algorithms and Google Maps). Motivation, raising awareness for the topics (e.g. navigating to a given location using Google Maps as well as a conventional map) . Introducing school students to graphs/trees and data structures (stack, queue; applying educational games, paper-and-pencil/unplugged exercises and programming exercises) . Introducing students to search algorithms, in particular depth-first (DFS) and breadth-first search (BFS) (paper- and-pencil exercise, group discussion regarding differences and advantages of those basic search algorithms, programming).Familiarizing students with intelligent agents (constructing a robot equipped with sensors). Programming a robot to explore a small maze (finding the exit) and evaluate, compare and document different search strategies/algorithms (random, wall-follow, DFS, BFS).

### **C. High School**

In this phase reading/writing abilities are fortified based on already existing knowledge, certain topics are explored in depth and new topics are introduced. According to this development and in line with our AI literacy concept the goal of this module (school students aged between 15 and 18 years) is to foster core AI topics by exploring them in a detailed way, introducing advanced AI topics as well as to foster the ability to acquire and apply AI topics independently [1], [6]. Following are an overview of the topics, structure and sample activities in this module. Automata (e.g. defining a finite state machine representing the simplified control of a vending machine). Intelligent agents, Graphs and data structures

(including sorting) (e.g. programming a robot to explore a small maze and building the corresponding graph). Problem solving by search. Classic planning and logic .Machine learning (e.g. discussing and analyzing different approaches to learning agents)

#### **D. University**

In order to follow analogy to reading/writing literacy, at university level we aim at a more fundamental understanding of the topics and the enabling of further developments in the field. In the context of AI that means the capability to describe problems formal, precise and on a much higher abstraction level. Also the understanding of properties of problems and the relation and the mapping of different problems is important because it allows reusing powerful solving methods. The university module consists of course-based education in the area of theory of computation and AI based on classical textbooks. In order to support a better learning we are following the idea of constructionism and use demonstrative hand-on exercises [6].

#### **Pilot Implementations And Preliminary Results**

Based on our AI education concept we developed, conducted and evaluated proof of concept implementations for each of the modules described in the previous sections.

#### **Evaluation Methodology**

The evaluation was done using a number of reliable qualitative and quantitative empirical research methods. In order to collect qualitative data we applied techniques of participant observation using both passive and active participation. Applying a grounded theory approach we collected and afterwards analyzed the collected qualitative data using open and selective coding. For each module and each age group appropriate evaluation methods were applied. Considering ethical and legal aspects all collected data were treated confidentially and personal information was made anonymous.

#### **A. Kindergarten**

The first module was implemented in a kindergarten in terms of a scientific project day. Ten different units dealing with AI/computer science topics were developed and carried out on separate hands on areas. According to the concept of peer teaching students of the school for kindergarten pedagogy hosted and explained the units to the kindergarten children accompanying them through their way of discovering and experiencing [8].

**Evaluation:** Preliminary results of a first analysis of collected data (mainly qualitative) indicate that our goal of introducing kindergarten children to fundamental AI/computer science topics in a playful way worked well. Video data, pictures and observations (field notes) during the project day indicate that children a) joyfully explored the different units and b) understood the (simplified) AI concepts and carried out most of the activities in each unit correctly. Semi-structured qualitative interviews with pedagogy school students and kindergarten pedagogues support these observations. For instance, after a short explanation/demonstration kindergarten children were able to sort LEGO bricks using the bubble sort algorithm.

#### **B. Middle School**

This module was implemented in form of a summer research week (three days, six hours per day) for middle school students at the university's robotics lab. In sum 24 school students (8% female, 92% male) with an average age of 12

years participated. Participants were familiar with the graphical LEGO programming language but had no prior knowledge in AI. To foster team- work, students worked in pairs. Respecting students' attention span those technical sessions were embedded in various other activities (games, sports, short soldering exercises) [1].

**Evaluation:** To evaluate this module on a broad basis we collected data from several sources applying various evaluation techniques: Assessing student's prior knowledge (group discussion). Foreign-evaluation of skills (13 item MCQ post-questionnaire; e.g. "What are the characteristics of depth- first search?") field notes (participant observation). Pictures and videos taken during the week, Students' feedback and self-evaluation post-questionnaire (3-point Likert scale; e.g. "How would you rate your knowledge about search algorithms?"). Students' solutions of the tasks (implemented programs). Student's documentations (results of their experiments). Students' final presentation of their work at the end of the week. Summarizing the results of the data analysis the objectives of this module have partly been met. On the one hand students got a basic understanding of graphs, trees and data structures (stack, queue) as well as of different search strategies and their characteristics (pros, cons). According to the feedback questionnaire and our observations students were enthusiastic and liked the tasks, which they described as challenging but not too difficult. On the other hand it turned out that students had problems to understand the connection between the basic AI concepts and their application (e.g. navigation systems). The reason might be that, due to lack of programming experience and lack of time, students were too focused on the programming task so they were notable to make connections and to see the overall picture. Therefore we either have to reduce the programming effort as well as the amount of topics addressed or to provide more time (e.g.by increasing number of days).

### C. High School

We conducted this pilot implementation as an elective course at a representative high school which integrates robotics in the regular curriculum. The course was held weekly by university researchers and comprised seven teaching units. In sum nine high school students with an average age of 16.5 years (1 female, 8 male) voluntarily participated. They all had prior knowledge in robotics (also in terms of participating in junior robotics competitions) but none in AI [1].

**Evaluation:** We evaluated this pilot implementation applying following evaluation techniques: Self-evaluation of skills post-questionnaire (3-point Likert scale; e.g. "I am able to explain the principles of the A\* search algorithm")

Feedback questionnaire on teaching style and structure of the units (openendedand5-pointLikertscalequestions..

Semi-structured qualitative interviews with each of the high school students (covering motivation, expectations, lessons learned, memorable topics/situations, experiences...). Collecting qualitative data by taking pictures and field notes during each teaching unit.

Summarizing the evaluation results, the pilot implementation succeeded in familiarizing high school students with a broad range of fundamental AI topics. Results indicate that students got a well-founded understanding of almost all AI literacy topics except for some sub-topics (architectures for agents, propositional logic). According to students' self-evaluation they had a very positive feeling about their gained knowledge.

#### D. University

At university level we have conducted a course on basic AI techniques at the bachelor level for several years. Besides topics such as logic or CSP (constraint satisfaction problem) we focused on the abstract description of dynamic systems or science studies at university. Like robots in order to allow to plan for this systems or to reason about. For this we use the situation calculus. The advantage of this representation is that it has a strong theoretical foundation based on first order logic and leads to elegant descriptions [7].

**Evaluation:** By using motivational hands-on exercises (controlling an agent in an environment and a teaching vehicle that is much handier but still focuses on the basic concepts of the situation calculus) almost all students now successfully complete the course (usually we have around hundred students in this course). After completing the course students have a deeper understanding of AI topics on a higher abstraction level.

#### Conclusion

In this we presented our approach of fostering AI literacy by using an analogy with the development of reading/writing literacy. In order to achieve this goal we developed a AI education concept for different age groups on different educational levels (kindergarten/primary school, middle school, high school, university).

We defined relevant AI literacy topics and described content and structure of the AI education concept as well as applied learning techniques and tools. Furthermore, we conducted and empirically evaluated four proofs of concept projects focusing on kindergarten, middle school, high school and university.

| Kindergarten              |   | Middle School                             |   |
|---------------------------|---|-------------------------------------------|---|
| graphs, data structures   | ● | graphs, trees, data structures; agents    | ● |
| sorting algorithms        | ● | search algorithms                         | ● |
| problem solving by search | ● | understand connection AI <-> applications | ● |
| High School               |   | University                                |   |
| automata                  | ● | profound understanding of AI topics       | ● |
| intelligent agents        | ● | formal problem description                | ● |
| graphs, data structures   | ● | abstraction ability on a higher level     | ● |
| problem solving by search | ● |                                           |   |
| classic planning, logic   | ● |                                           |   |
| machine learning          | ● |                                           |   |
|                           |   | succeeded                                 | ● |
|                           |   | partly succeeded                          | ● |
|                           |   | not succeeded                             | ● |

Fig.3. Overview of topics and Evaluated result

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