Introducing Artificial Intelligence to Secondary Schools Through STEM Learning and the Logic Programming Language Prolog

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***Abstract* – This article proposes a project aimed at introducing secondary school students to artificial intelligence and logic programming using the Prolog language. In commemoration of the 50th anniversary of Prolog's development, the authors participate in the international initiative "Prolog Education and Thinking" through the "Digital Bulgaria in Prolog" activity, implemented in Bulgarian secondary schools. The article offers a concise overview of a STEM (Science, Technology, Engineering, and Mathematics) educational program and training for secondary school students in Bulgaria. STEM serves as a project-based learning approach, fostering students' understanding of multiple disciplines and utilizing diverse technologies to enhance their skills. Additionally, the article showcases examples of student initiatives spanning natural sciences, informatics, humanities, culture, and art, illustrating the interdisciplinary nature of STEM education.**

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1. Introduction

The integration of artificial intelligence (AI) across various sectors closely aligns with the advancement of digital technologies [1]. In the context of Industry 4.0, AI is taking on an increasingly important role in addressing new challenges and goals [2].

The European Community's White Paper on Artificial Intelligence [3] outlines key principles for the advancement of AI and highlights the need to develop the skills required for AI-related work. Consequently, there arises a necessity for corresponding adaptations within the educational systems of European nations. The Committee on Culture and Education of the European Parliament (CULT) has made a comprehensive study, taking into account the need to train professionals capable of using intellectual approaches in modern business and services [4]. This highlights the importance of educators and education professionals actively involved in AI development and utilization, facilitating students' preparedness for ongoing and forthcoming societal transformations [5]. These topics are further developed in [6].

STEM is described as a model that combines science, technology, engineering, and mathematics in educational programs to prepare students for the next stage of their lives – graduate school or work. It also develops their talents for the knowledge industries of the future. In STEM education, students are expected to (1) engage in scientific inquiry, (2) develop logical thinking skills, (3) have collaborative abilities, and (4) hone analytical skills.

In essence, education through STEM focuses not only on the transfer of knowledge between disciplines but also emphasizes the learning process of students by integrating learning into everyday life. Illustrated STEM Learning with Prolog Logic Programming promotes logical and declarative thinking by engaging students in active transdisciplinary, project-based learning. Thus, this article presents an approach and shares experiences in implementing such training within Bulgarian secondary schools.

The definition of artificial intelligence as delineated in the Draft Legislation on Artificial Intelligence (AI) of the European Commission [7] is articulated as follows: ""Artificial intelligence system" (AI system) means software that is developed with one or more of the techniques and approaches listed in Annex I and can, for a given set of human-defined objectives, generate outputs such as content, predictions, recommendations, or decisions influencing the environments they interact with".

Secondly, the techniques and approaches listed in Annex I state [7]: "Logic- and knowledge-based approaches, including knowledge representation, inductive (logic) programming, knowledge bases, inference and deductive engines, (symbolic) reasoning, and expert systems".

Artificial intelligence heavily relies on knowledge and its application within the dynamic landscape of science and technology. AI systems transcend mere task execution; they possess the capability to learn, adapt, and comprehend the surrounding world, facilitated by a foundational repository of general knowledge.

The strategic documents cited above lay a solid foundation for the advancement of AI systems, delineating crucial directions for the study and integration of AI within school education. These include the development of tailored curricula for secondary school students, the provision of specialized training to educators for AI instruction, and the creation of pertinent learning materials.

Why Prolog? Through the activity "Digital Bulgaria in Prolog" (part of the international initiative known as "Prolog Education and Thinking"), working with a group of scientists from all over the world, Prolog logic programming is introduced in secondary school. One of the creators of the language, Robert Kowalski, is also part of this group. Prolog is particularly useful for solving problems in AI, as well as in areas such as search, planning, and knowledge representation.

Prolog – a logic programming language, plays a crucial role in artificial intelligence. Unlike many other programming languages, Prolog is primarily designed as a declarative language. In Prolog, logic is expressed through relations, which consist of facts and rules. Instead of delineating a linear sequence of actions typical of algorithmic languages, Prolog programs concentrate on deducing conclusions from these facts and rules. When solving problems, Prolog describes the situation using rules and facts, and the goal is explicitly stated. The Prolog interpreter then provides solutions. Notably, Prolog excels in AI problem-solving, search algorithms, planning, and knowledge representation. An intriguing facet lies in its capacity to ascertain all potential solutions, rather than merely one when exploring alternatives. As stated above, the logical approach (the Prolog language) is fundamental to knowledge modeling. Also, Prolog programming is easy and understandable because it is close to natural language. This also leads to easy comprehension across diverse age groups, making it applicable to various secondary school subjects. For example, in [8], logic programming is argued to be a viable and desirable choice of paradigm for primary school children, experimenting with 8- to 10-year-old children in two public primary schools in Argentina. In [9], the authors suggest that using and learning Prolog for most of the topics in the high school math curriculum (probability, algebra, analysis, or geometry) allows for better mastery of course concepts. The article [10] presents an introduction to Prolog programming education. The secondary school discussed in the paper [11] provides an overview of the use of Prolog and its derivatives that sustain research and development in the fields of bioinformatics and computational biology. An overview of tools for automated reasoning in geometry developed in Prolog is concisely outlined in the paper [12]. All these findings serve as motivation for us to select Prolog as the primary tool for implementing STEM education. Through its use, the aim is to integrate Prolog into secondary school curricula and address the challenges of the digitization of Bulgarian folklore through the "Digital Bulgaria in Prolog" initiative, in which the authors are actively participating within the "Prolog Education and Thinking" initiative.

2. Methodology – Introducing AI in Secondary Schools in Bulgaria

In communication with different schools in Bulgaria, the idea of introducing artificial intelligence in secondary school was born. At the same time, a strategy for the development of artificial intelligence until 2030 in Bulgaria was published, including artificial intelligence in education and science. For the realization of this idea, an appropriate curriculum was prepared, teachers were trained, and learning resources were prepared.

2.1. Curriculum Development

The Bulgarian Ministry of Education is creating a network of innovative schools that embrace novel teaching methodologies and content [13]. Among these institutions is the Academic Kiril Popov Mathematical High School, which has developed a training program in artificial intelligence (AI) for high school students. This program has been adapted and shared with other schools, and the results show that AI can be successfully integrated across various types of classes and different age groups. Students' interest and motivation in AI are growing, suggesting that it can be a valuable addition to the school curriculum [14].

In 2023, the authors created an innovative STEM education program for students at a vocational high school in Plovdiv, Bulgaria. This program seamlessly incorporates technology into the science and mathematics curricula. It fosters collaboration between students and teachers within the school's STEM center. Moreover, it actively promotes research and teaching in the fields of mathematics and science. The program adopts a multifaceted and globally-oriented approach, aimed at providing students with a comprehensive perspective. Notably, it also introduces artificial intelligence technologies and employs project-based learning strategies.

The program is prepared for two academic years and consists of two parts. During the first year, students delve into the topic of "Artificial Intelligence – Logical Prolog Programming", while in the second year, they focus on" Artificial Intelligence - Project Development Process through the Prolog language".

The "Artificial Intelligence – Prolog Logical Programming" program covers the fundamental principles of classical artificial intelligence, introducing students to Prolog logic programming. It explores various topics including knowledge modeling, knowledge base design, information retrieval, knowledge processing, and semantic technologies. Moreover, it delves into the domain of expert systems, offering students a comprehensive understanding of the subject matter. Additionally, it investigates the realm of expert systems.

On the other hand, the "Artificial Intelligence – Project Development Process using Prolog" program aims to equip students with in-depth theoretical knowledge in the field of intelligent systems. It also imparts practical skills related to software project development using methods and techniques of artificial intelligence. The curriculum includes theoretical foundations for iterative software development in the logic programming language Prolog.

Logic and knowledge representation are pivotal in the progress of artificial intelligence. Within the field of AI, the logical aspect centers on employing formal structures to represent and handle knowledge. These structures empower systems to tackle intricate problems. In the logical branch of AI, programming relies on a formal logical framework. Programs are constructed based on rules and facts, serving as representations of knowledge. This approach, known as logic programming, is utilized to develop expert systems and intelligent agents.

2.2. Teacher Training

Teacher training is extremely important in this process, as the majority of instructors have not studied the logic programming language Prolog and AI during their university education. Also, due to the specificity of the subject, systematic training of teachers is necessary.

Given the inclusion of this STEM subject in the school curriculum, teachers received training in the programming language Prolog. Educators specializing in natural sciences (biology, chemistry, physics), mathematics, informatics, and information technology participated in the training. Following the teachers' qualification, they proposed the development of a collaborative project to be implemented using the Prolog language. This initiative demonstrates their competence in preparing project assignments for students and supporting their implementation effectively.

2.3. Study Materials

Upon completing the training, the teachers proceed to prepare project assignments for their students. These assignments serve as methodological materials, detailing the specific topic, objectives, tasks, evaluation criteria, and other pertinent information. Additionally, the assignment includes references to sources and literature essential for students to develop the project effectively. During the subsequent stages of project development, students receive guidance and recommendations from both their teachers and specialists in the relevant field. This guidance assists students in determining the objects and relationships necessary for making appropriate classifications within their projects.

3. Results

One of the goals of experiential learning is to emphasize that Prolog is a convenient means of representing and processing common sense knowledge.

For this reason, the course includes examples from various disciplines studied at school, such as biology, chemistry, physics, history, geography, literature, cultural heritage, etc. In this sense, one of the main approaches in the conducted experimental education is the creation of a system of learning tasks related to the knowledge of the students both in different educational subjects and with problems from their everyday lives. The conclusion that can be drawn is that students like this type of learning.

In addition, there is increased interest in the disciplines covered by the examples.

3.1. Development of Student Projects

The student projects are categorized into subjects related to various disciplines such as biology, chemistry, physics, literature, geography, and more. Below are some of these projects developed by students.

```
%Create a database of different classes, species and orders of animals
% Class: class(name, order, distinguishing_characteristics, food, habitat).
 %For example:
bird(swallow, flying, developed_wings, worms, europa).
bird(penguin, floating, has_fins, fish, antractidae).
bird(ostrich, running, stunted_wings, plant_food, africa).
 % Class: Mammals
mammal(lion, predator, carnivore, meat, africa).
mammal(marmot, rodent, hibernation, herbivore, alpine).
mammal(chimpanzee, primate, humanoid, plant_food, africa).
 % Class: Reptiles
reptile(cinderella, scaly, venomous_snake, carnivorous, bulgarian).
reptile(turtle, turtles, has_shell, plant_food, bulgaria).
reptile(alligator, crocodiles, flat_head, carnivore, america).
 % Class: Amphibians
amphibian(water_frog, tailless, floating_snails, carnivore, bulgaria).
amphibian(rainbow, tails, bright yellow_spots, insects, europe).
amphibian(swamp_tree, legless, green_color, insects, bulgaria).
 % Class: Pisces
fish(shark, cartilaginous, torpedo_shaped, carnivore, pacific_ocean).
fish(sea_fox, bony, demersal_fish, carnivorous, black_sea).
```

Figure 1. A knowledge base with different classes, species, and orders of animals

The first example is related to the subjects of biology and informatics. Teachers are devising a project assignment where students are tasked with classifying animals and detailing their diverse characteristics. In the current classification process, students construct a knowledge base by defining objects and their interrelations, subsequently establishing rules governing the validity of these relationships. These statements, known as facts and rules, form the cornerstone of their analysis. The students have so far analyzed the given problem by studying literature on the topic and defining objects, relations, and characteristics.

Initially, biology and informatics teachers are actively guiding students in the project. Subsequently, teachers from disciplines such as chemistry, physics, and geography will participate in the initiative. Additionally, the project will incorporate animal characteristics related to other natural sciences and the geography of animal habitats.

In the design phase, students outline the objects, their interrelations, and the specific characteristics they possess. A classification by levels is being prepared. Following this, they consider the implementation through the Prolog inference engine.

```prolog
% Database with different classes, species and orders of animals
% Class: class(name, order, distinguishing_characteristics, food, habitat).
bird(swallow, flying, developed_wings, worms, europa).
bird(penguin, floating, has_fins, fish, antractidae).
bird(ostrich, running, stunted_wings, plant_food, africa).
% Predicate for knowing animals
guess_the_animal :-
     write('Select Animal Class (Bird/Mammal/Reptile/Amphibian/Fish): '), read(Class),
     (   Class = bird -> guess_bird;
         Class = mammal -> guess_mammal;
         Class = reptile -> guess_reptile;
         Class = amphibian -> guess_amphibian;
         Class = fish -> guess_fish;
         write('Invalid class. Try again.'), nl     ).
% Predicates for recognition of birds, mammals and reptiles
guess_bird :-
     write('What is the type of bird: flying, floating or running)? '), read(Type),
     (   (Type = flying; Type = floating; Type = running) -> recognize_bird;
         write('Invalid species for bird. Try again.'), nl     ).
% Predicates for species recognition in class Birds
recognize_bird :-
     write('What are the distinguishing characteristics of the bird? For example: developed_wings, has_fins, stunted_wings?'),
    read(Distinctive_Characteristics),
     (  (Distinctive_Characteristics = developed_wings; Distinctive_Characteristics = has_fins;
         Distinctive_Characteristics = stunted_wings) -> the_bird_is;
         write('Invalid species for bird. Try again.'), nl     ).
the_bird_is :-
     write('What does the bird eat: worms, fish, plant_food? '), read(Food),
     ( bird(Name, Order, Distinctive_Characteristics, Food, Habitat)
         -> write('Animal is '), write(Name), nl,
              write('Order: '), write(Order), nl,
              write('Distinguishing Characteristics: '), write(Distinctive_Characteristics), nl,
              write('Habitat: '), write(Habitat), nl;
         write('Invalid running mammal sequence. Try again.'), nl     ).
% Main predicate starting the program
play :-
     write('Welcome to the game "Guess the Animal"!'), nl,
     write('Choose one of the following animals and I will guess it: swallow, penguin, ostrich, lion, groundhog, chimpanzee, viper, turtle, alligator,
            water frog, rain frog, swamp woodpecker, shark, sea fox'), nl,
     write('Answer the following questions to know the animal:'), nl,
     guess_the_animal,
     continue_game.
% Predicate to continue the game
continue_game :-
     write('Do you want to play again? (yes/no) '), read(Answer),
     (   Answer = yes -> play;
         Answer = no, write('See you soon!'), nl     ).
% We start the game
start :-  play.
```

Figure 2. Defining facts and rules in Prolog

Project development is ongoing, with testing yet to be conducted. At this stage, the description of facts (Fig. 1) and rules (Fig. 2) in the Prolog language [15] is being implemented.

The construction of the knowledge base for this specialized field is currently underway, with active participation from all science teachers. By the end of the school year, each student will have contributed to building a portion of the knowledge base, culminating in the assembly of a comprehensive Prolog program.

Students are tasked with constructing predicate rules to facilitate animal identification, as illustrated in Fig. 3. Additionally, they are responsible for creating predicates governing the actions within the game and ensuring its continuity, as depicted in the same figure.

The second example is related to the subjects of chemistry and physics. Students initiate their inquiry with an examination of a problem set by the teacher, focusing on the subject of “Mineral springs in Bulgaria”.

They follow a similar approach to the first example, embarking on a thorough exploration of relevant literature to gather insights into the topic. During this process, they define key objects, establish relationships, and identify essential characteristics associated with mineral springs. Chemistry, physics, and informatics teachers play pivotal roles here.

Bulgaria boasts numerous mineral springs [16], [17], encompassing nearly all known natural water types based on their physics-chemical characteristics [18]. In their endeavor to develop a mineral water project utilizing the Prolog language, students follow the software development process, navigating through the phases of analysis, design, development, and testing.

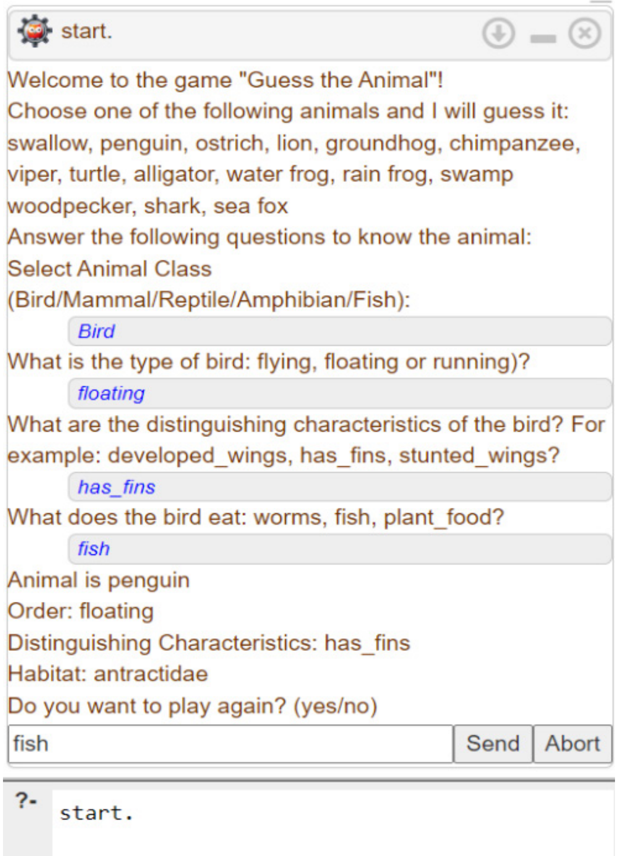

Figure 3. Results of running the program

During the analysis stage, students study literature on mineral springs in Bulgaria to determine objects, connections, and characteristics. Subsequently, in the design phase, students delineate objects, establish connections between them, and outline their characteristics. They categorize these characteristics based on location, as well as the physical and chemical properties of the mineral water, as detailed in Table 1 [19]. The students are currently in the development and testing stage, where they describe facts and rules (Fig. 4) in the Prolog language.

Table 1. Characteristics of several sources

	T °C	M mg /l	pH	HCO3	SO4	Cl	No
Izvoriste (Southeast regions)	24	460	7,8	256	34	15	84
Velingrad (south central regions)	22	1976	9.15	24	26	4	50
Devin (south central regions)	44	223	9.4	101	20	2	70
Bankia (southwest regions)	20	417	7.3	297	10	3	16
Separeva bania (southwest regions)	57	707	9.4	116	244	30	212

```
% %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
% % Module: Mineral springs of Bulgaria
% Characteristics of mineral springs
% Knowledge base      mineral_spring(Name, [temperature,460,7.8,256,34,15,84]).
mineral_spring('Izvoriste', [24,460,7.8,256,34,15,84]).
mineral_spring('Velingrad', [22,1976,9.15,24,26,4,50]).
mineral_spring('Devin', [44,223,9.4,101,20,2,70]).
mineral_spring('Bankia', [20,417,7.3,297,10,3,16]).
mineral_spring('Separeva bania', [57,707,9.4,116,244,30,212]).
% Classification of mineral waters according to temperature
cold(Source) :-
mineral_source(Source, [T,_,_,_,_,_,_]), T < 37.
warm(Source) :-
mineral_source(Source, [T,_,_,_,_,_,_]), T > 37, T =< 60.
hot(Source):-
mineral_source(Source, [T,_,_,_,_,_,_]), T > 60.
```

Figure 4. Knowledge base and predicates for mineral waters according to their characteristics

A knowledge base is being built for the specific area. At this stage, the students have familiarized themselves with the necessary scientific literature and have determined the chemical and physical properties of the mineral water, by which a specific spring can be identified. Progressing further on this project topic, students are tasked with selecting the visualization method for Prolog inferences. The active involvement of chemistry, physics, and informatics teachers underscores the interdisciplinary nature of the project. Moreover, geography and history teachers will contribute to the development of additional modules focusing on the geographical and historical aspects of individual mineral springs. The project's concept and implementation have already been discussed in [20].

The construction of the domain-specific knowledge base is described by rules and facts in the Prolog language as follows: mineral_spring(Spring, [T,M,PH,HCO3,SO4,CI,Na]). In this predicate, the first argument, denoted by Spring, represents the variable holding the location (name) of the spring. The second argument is a list encompassing seven positions, each corresponding to specific water characteristics. The positions are designated for water temperature (T), minerals (M), pH level (PH), and so forth [20].

The third example pertains to the cultural and historical heritage of Bulgaria, where students focus on gathering information about Bulgarian folk costumes.

Every nation boasts its own unique traditional clothing, but today's youth are often unaware of these cultural roots. The authors seek to revive this connection and encourage appreciation of the tradition by offering insight into trivia.

```
region('Northern').
region('Dobruja').
region('Strandja').
region('Thracian').
region('Rhodope').
region('Pirin').
region('Shop').
hat('cilindrincal kalpak').
shirt(man_tumnik_northern_region).
coat(big_coat_northern_region).
coat(dolaktanka_northern_region).
coat(gluhche_northern_region).
trousers(benevrek_northern_region).
trousers(poturi_northern_region).
belt(man_belt_northern_region).

white_colored_costume :-    region('Northern'),
                            hat('cilindrincal kalpak'),
                            shirt(man_tumnik_northern_region),
                            ( coat(big_coat_northern_region);
                            coat(dolaktanka_northern_region);
                            coat(gluhche_northern_region)),
                            ( trousers(benevrek_northern_region);
                            trousers(poturi_northern_region)),
                            belt(man_belt_northern_region).
```

Figure 5. Facts and rules about white shirt men's costume

Students gather information about folk costumes in Bulgaria and begin to dissect the intricate components of these garments, exploring the objects and relationships therein. They categorize the characteristics of folk costumes based on their respective regions (Severna, Dobrudja, Strandja, Thrace, Rhodope, Pirin, and Shop), as well as their gender specificity – male or female. For instance, Figure 5 elucidates the facts and rules in Prolog .language about a specific male folk attire: the white-colored northern costume. Its elements are of a special type; for example, the outer garment is a dolaktanka from the Northern folklore region, the cap is cylindrical, etc. [22]. These elements are also integral parts of the costume ontology already developed, as briefly outlined in [21].

3.2. Acquiring Key Competencies and Establishing Intersubject Connections

Throughout the Prolog logic programming training, students underwent assessment tasks focused on acquiring the necessary knowledge and skills for effectively utilizing a logic programming environment.

A pedagogical investigation was conducted to ascertain the students' success rates across various stages of the educational journey. Evaluation criteria included:

- K1: Definition of Facts and Rules;
- K2: Understanding the meaning of recursion and applying it correctly;
- K3: Unification and built-in predicates;
- K4: Return Mechanism;
- K5: Use of lists;
- K6: Search methods;
- K7: Create an application.

The research used criterion-oriented diagnostics, which relies on centrally established norms and requirements (standards, programs) as a basis for assessment. They are used for comparison with the individual achievements of learners.

The research uses tasks reflecting the degree of overlap between normatively determined lists of knowledge, skills, activities, etc.

According to the number of measurements, two types of procedures are used in the study:

- to establish the condition of the studied object at a specific moment (one-time measurement).
- to register successive changes in the object (multiple measurements).

The areas of application are:

- Microdiagnosis: of individuals and groups.
- Macro diagnostics: the effectiveness of innovations in education.

Diagnostics of the final results involve measuring and evaluating the learning outcomes according to pre-established criteria outlined in the curriculum.

The formative experiment is conducted following 32 teaching hours per week, equivalent to one year of study, within the experimental learning process. Its purpose is to track the evolution of the outcomes resulting from the implementation of the devised methodology.

The pedagogical experiment was conducted in the 2023–2024 school year with groups of students from the 8th grade studying according to the proposed curriculum. The criteria by which the one-year training is evaluated are aligned with the curriculum and the expected results. The following table presents the main criteria and their weight, which are the basis for the assessment.

3.3. Analysis of the Results of the Assignments

The total number of students participating in the experimental study is 53.

From Figure 6 and Table 2, it can be seen that students quickly mastered the definition of facts and rules in Prolog as well as understanding the meaning of recursion and its application. However, they encountered challenges in comprehending how the inference engine works. Particularly, they had the most difficulties using lists and understanding and applying search methods, since they study imperative programming languages (C#) in their mandatory training.

In general, students cope with the description of a problem and can create applications in the Prolog language.

Table 2. Taylor matrix

ASSIGNMENT CONTENT FRAMEWORK						
Learning content	**Categories of mental work, according to Bloom's Taxonomy**					
	Knowledge	understanding	Application	Analysis	Synthesis	Assessment
Definition of Facts and Rules	Task1	Task1		Task1		
Understanding the meaning of recursion and applying it correctly	Task3	Task13	Task4	Task3	Task3	
Unification and built-in predicates	Task1, Task2, Task3	Task1, Task2, Task3	Task2, Task3	Task1, Task3	Task1, Task3	Task1
Return Mechanism	Task2, Task3	Task2, Task3, Task4	Task2, Task3	Task2, Task3, Task4	Task2, Task3,	Task2, Task3,
Use of lists	Task3, Task4	Task3, Task4	Task3	Task3	Task4	Task4
Search methods	Task4, Task5	Task4, Task5	Task3, Task4	Task4, Task5		
Create an application	Task1, Task2, Task3, Task4, Task5	Task1, Task2, Task3, Task4, Task5	Task1, Task2, Task3, Task4, Task5	Task1, Task2, Task3,	Task4, Task5	Task5

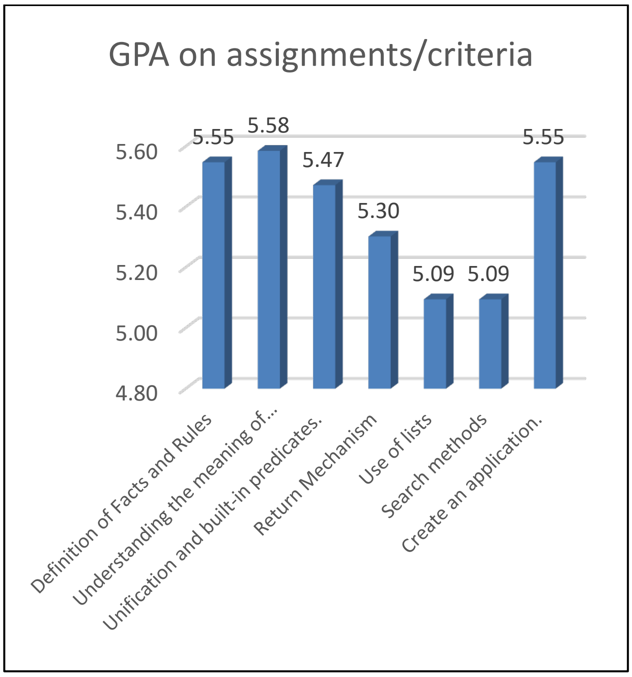

Figure 6. GPA on assignments/criteria

The analysis of the experiment results determined the need to continue the studies in several areas:

- Development of teaching materials and methodological resources
- Expanding the system of learning tasks covering the curriculum topics.
- Conducting additional research to implement the curriculum in other schools catering to students of varying age groups.

4. Discussion

Solving a problem in Prolog means describing it, as seen in the examples used. No matter how varied the description, Prolog always returns an answer. In this direction, the need for learning resources and educational methodological approaches has been analyzed, and various areas of application have been presented. A pilot study was conducted, and the results show that students can solve problems naturally with logic programming by focusing on key concepts of computational thinking, including abstraction, knowledge representation, and reasoning.

Although preliminary results are encouraging, efforts should be made to determine how teachers of various subjects can be trained to deliver logic programming instruction. Continued efforts are also needed to develop teaching materials and support resources for teachers and students. Thus, Prolog logic programming can be introduced naturally and effectively by tapping into students' existing skills and around topics that excite and concern them.

The presented sample projects and the "Digital Bulgaria in Prolog" initiative will inspire a new generation of students by introducing them to a convenient, logic-based programming language. Students will also acquire knowledge related to other subject areas they study, including natural sciences, mathematics, informatics, history, geography, etc., and understand how this knowledge can be represented in intelligent systems. The students' creative and abstract thinking will be stimulated and their interest in the cultural and historical heritage of Bulgaria will be strengthened.

The development of teaching materials in STEM is expected to increase interest in other academic disciplines such as history and geography of Bulgaria, Bulgarian cultural and historical heritage, and Bulgarian folklore. This venture could be a continuation of efforts to introduce AI learning in secondary schools.

5. Conclusion

The article aims to show a real-world example of learning in a STEM environment where students delve into artificial intelligence (AI) through Prolog logic programming. These student projects cover a variety of fields, including natural sciences, informatics, mathematics, history, geography, and cultural heritage.

Embracing STEM education, teachers from different disciplines collaborate as a team, emphasizing the importance of integrating multiple subject areas.

STEM, conceptualized as a transdisciplinary approach to teaching, promotes problem-solving by using insights from different fields. From initial discussion to problem resolution, this approach encourages critical, logical, and systematic thinking. The integration of AI and Prolog programming gives learners global competitiveness, while metacognitive activities improve the logical thinking of both students and teachers. Overall, STEM-based learning provides comprehensive opportunities for students to improve their thinking skills across subjects, thereby becoming more competitive in the job market.

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