The teacher’s role in discovery, preparation, and development of gifted students in the field of informatics

G. Atanasova, P. Hristova *
* University of Rousse, IIT Department, Rousse, Bulgaria
gatanasova@uni-ruse.bg

Abstract - The national development strategies of many countries prioritize the stronger orientation to an economy based on the knowledge, on the development of research work, and technological development and innovation. Bulgaria is one of the few countries in the world that offers young students the opportunity to study computer science from a very early age in extracurricular classes and also organizes contests in computer science for students of secondary school classes. As a result, Bulgarian students can be recognized on average as the priorities of international information competitions. The role of teachers in discovering and preparing gifted children for such competitions is an irrevocable and challenging task. Teachers need to use focused and well-planned approaches. The general didactic principles for creating a learning process are presented. Essential for the successful preparation of future medalists is the early start of learning the basic principles of programming. Some of the fundamental practical situations that show the significant role of the teacher are presented. Proof of the applicability of the proposed approach is the performance by years of students from the school in Rousse.

Keywords - teachers' support, gifted trainee, student's competitions in programming, pedagogical approaches

I. INTRODUCTION

The necessity for a modern knowledge-based information society development places serious demands on educational institutions. They are called upon to prepare both computer literate citizens and highly qualified software specialists. This problem has been identified as essential within the European Union (EU). In the Europe 2020 strategy, special attention is given to EU countries "to ensure sufficient availability of cadres with natural, mathematical and engineering education and to focus school curricula on creative, innovative and entrepreneurial thinking" [1]. This EU Directive is in line with the approach taken in Bulgaria and the multiannual efforts of teachers and university lecturers to involve early adolescents in towards new technologies and informatics and build a lasting interest. Bulgaria has traditions and achievements in preparing little students to participate in competitions in informatics from an early age. Not accidentally, the country was the initiator and host of the first European Junior Olympiad in Informatics (EJOI) in the year 2017 [2]. Organizing out-of-the-classroom informatics curricula enables gradual and consistent learning of algorithms and programming skills using natural children's interest in computers from computer games. The positive results achievement is closely related to the answers to the following two important questions: What should be empowered teaching children and are there any teachers to train them? The work on the discovery, preparation, and development of young talents in the field of informatics has its specificities that need to be taken into account. Recently, more and more scientists have been drawing attention to the means used for little students’ preparation in out-of-the-classroom computer science schools. In Bulgaria, many authors discuss mentioned above questions in their works. Some authors make an exhaustive analysis of the informatics and information technologies curricula in Bulgarian schools [3], [4]. They also outline the history and evolution of the competitions and the Olympiads in Informatics. Some of them suggest approaches for managing the building of the participants in the Olympiads of Informatics and IT. The suggested models, more often, are presented as a system of basic tasks for prominent students’ preparation for participation in the Olympiads in Informatics. Other Bulgarian author offers a spiraling approach to train 10 - 11-year-old children in informatics [5]. In her previous work, Hristova offers an objective approach for organizing the extra-curricular work in Informatics for pupils up to the 5th grade [6].

According to N. Wirth, "Programming is a constructive art" the question is: What approaches and methods should be appropriate to prepare the beginner students to master this creative activity so to ensure high quality and feasibility (methodical, cognitive, and organizational) of this training? [4].

The role of the teacher as a person, a specialist in informatics, and a scientist to achieve the ultimate goal is irrevocable. Still, the research related to the preparation and requirements of lecturers which preparing students for contests in Informatics is relatively small. There is a necessity from scientifically based approaches to work for both the pedagogic and informatics. The purpose of the present work is to offer a scientific ground approach to the work of the teachers in the discovering and preparation of gifted children for programming competitions. The hypothesis is the application of the pedagogical principles in the learning process will give a chance of a teacher to increase the number of successful competitors.
II. METHODOLOGY

A. Didactic Principles In The Programming Training Process

A scientific approach has been based on established scientific considerations. In this regard, based on an analysis of general didactic principles for building a learning sequence, their applicability was sought to prepare gifted children for programming. Prof. Petrov defines the principles of education as a system of basic positions, leading ideas, or general requirements. He outlines the overall activity of the trainees and the teachers in the learning process [7]. They are the theoretical basis for determining the content, so they have an essential place in the pedagogical science that determines the proper planning and implementation of the learning process. It follows each principle description in the context of the specific work of teachers in the preparation of competitors in informatics:

1) Principle of scientific excellence. It relies on the normative link between science and the subject matter. This principle requires the content to comprise objective scientific facts, concepts, laws, theories of the field concerned, and to reveal contemporary scientific achievements. Focused on the components of the learning process in programming training, this principle defines scientifically determined to learn programming objectives and scientifically refined algorithmic tasks addressing contemporary scientific problems, using scientifically proven methods and approaches to constructing algorithms, forming concepts, laws, theoretical formulations and practical realization in a specific programming language.

2) Principle of visibility. The visibility provides the primary perception of the subjects studied, included in the curriculum, and the construction of the concept. This principle describes how it is ensured the transition from the concrete to the abstract through sensory support. This principle of visibility, in general, can be denoted by the requirement to use visual aids in the educational process. The main factor that directly stimulates the activity and consciousness of learners in the learning process. This principle is particularly important for quality education programming and has a high value for the practical training of future contestants. Each algorithm operator, the change of the value of the variables, and the path for transforming the input data into the desired results are visual perception. In the programming training, conditional visual and dynamic visualization is applicable, the first being provided by the graphical representation of the algorithms and the second using animation environments or visualization of algorithms. The result is an increased observance and abstract thinking in small contestants.

3) Principle of consciousness. This principle is the unity between the learner's learning attitude and the understanding of the learning material. Consciousness is an essential prerequisite for overcoming the mechanical learning of learning information. Consciousness as personality quality is expressed as unity between intellectual, emotional, and behavioral activity.

4) Principle of activity. The essence of this principle is the conscious and active perception of the studied subject, its rationalization, creative processing, and application. It is aware of the bilateral relationship between the subjects in the learning process - the active and conscious position grows in awareness of the goals and activation of the cognitive activity of the trainees [8].

Objectives in the preparation of students for participation in programming competitions can be decomposed into intermediate and specific learning objectives so to provide a motivating pedagogical impact in planning and organizing the learning process. How the learning process in the preparation part is carried out is essential for increasing the motivation for adopting an active and conscious role of the students in education. The stimulation of mental activity and consciousness in the programming training is directly dependent on the methods and techniques used with proven activation value such as problem situations, practical tasks, situations suggestive of creative decisions. Activity and consciousness are the basis for creating a prerequisite for successful programming competitors.

5) Accessibility principle. Accessibility is the guiding principle for the didactic transformation of scientific information into the learning content of a subject. Accessibility requires full coordination between objectives, learning content; age, and mental characteristics of learners; methods and means of learning which enable knowledge, skills, and habits to be controlled by tensions of the forces for a regulated time [9]. The principle requires the presentation of scientific knowledge to be carried out systematically and consistently, well-reasoned, based on the planned schooling time and the psycho-physiological characteristics of the trainees. A specific problem with the application of this principle is the difficulty measure how to determine the optimal option. [9].

The following didactic rules formulated by Comenius in the Great Didactics as early as the 17th century are applied to successfully developing talented children in programming. [10]:

- from easy to difficult - a gradual transition from well-absorbed knowledge to learning knowledge that causes difficulty and requires more intellectual and emotional effort;
- from the known to the unknown - the learning of the new knowledge is based on the previous life experience theoretical knowledge and practical habits and skills;
- from the simple to the complex - begins with the absorption of more elementary concepts, facts, regularities and a smooth transition to more complex ones;
- from the close to the distant - the cognitive horizons are gradually expanding.

6) Principle of System and Consistency. The basis of this principle lies in the systematic nature of science. The scientific logic of the subjects studied, and the regularities in the development of the learners' thinking. Comenius postulates to go from facts to conclusions, from examples
to rules to expose the teaching material as a system. "This principle requires knowledge, skills, and habits to form a particular order in which each element of the material has relation to others" [9]. The principle of orderliness also manifests itself in all components of the training process in the field of informatics: orderliness towards learning objectives means a complete project of the professional qualities of the personality that is in line with the curriculum, fundamental and advanced in the knowledge and skills in the field of algorithms and specific programming language; establishing links between individual sub algorithms and methods for their creation to create a holistic view of the subject studied and to create a practical opportunity to solve tasks of a different nature; the educational technologies, forms, and methods designed in a rational and efficient system in a consistent logical order; the activity of the trainees is motivated and planned rationally, systematically and consistently to earn the knowledge and skills.

7) Principle of permanent knowledge and skills. The essence of this principle is to provide in-depth knowledge, skills, and habits. The goal is to create an opportunity for learners to use learning as a basis for future intellectual activity and solving practical tasks. "Permanent is that knowledge that retained for a long time in the students' minds and can be reproduced without much effort and applied in new different situations". [7].

8) The principle of individual approach. This principle concerns the fact that the process of acquiring knowledge and skills is strictly personal. Its application implies the differentiation of the teaching activity according to the individual characteristics of gifted children. Individualization is achieved toward approaches, methods, forms, and means of differentiating the teaching work: personal curriculum, cognitive complexity tasks, and more.

B. The Role of Teachers in the Extracurricular Schools of Informatics

Training in programming for students aged 9-14 is specific. It demands compliance with the age characteristics of children. The term "trainer" is more appropriate and more precise when it comes to extracurricular training. A trainer in extracurricular computer science can be everyone who has the task of transferring his or her knowledge and skills in informatics in useful for the trainee.

The proposed approach combines the described didactic principles and consists of the following: the trainer explains, demonstrates various algorithmic problems. The learners earn and train until they master the knowledge at their rate. Students with high interest in the field of informatics are involved in the training. They need to expand their knowledge in the field of informatics, acquire practical programming skills, and deeply study basic algorithms for working with complex data structures and gain experience in solving non-standard tasks. In this connection, the role of the teacher is crucial for both beginners and established contestants.

The systematic approach is needed to be expanded and deepened, taking into account the specifics of the informatics for young students. The focus is on rapidly basic programming knowledge acquiring. Pupils have to understand it by developing as many algorithms as possible to solve. The teacher has to select and arrange learning tasks. The end goal is competitors to master tasks close to the practice. It is not enough for them to reproduce known algorithms. Often students have to combine and modifying a set of already known algorithmic steps, as well as compiling new ones. Every programming competition requires a successful deal with complex formal objects. So the teacher has to train students to develop mathematical knowledge, logical, systemic, and algorithmic thinking. The initial preparation of small talents involves the acquisition of knowledge and skills of diverse aspects. Essential knowledge units are purely programming skills, mathematics, information technologies, and logic. Insufficient absorption of some knowledge leads to unwanted failures and disappointments at a later stage. The complex nature of the preparation can initially stress and overwhelm the students. For this reason, the teacher should give new knowledge very carefully for enough time. Figure 1 depicts the training steps in ascending order [11].

The first step is beginners to acquire excellent computer literacy. Students have to adhere to working with a personal computer and learn some commands of the operating system through game tasks. Early age is a period of functional literacy of children. Computer literacy has significant importance for future motivation. In the beginning, the teacher has the responsible task to show the students that the computer is used not only for games but also for work.

The second step is training in algorithms. Learners need to learn to create algorithms to solve the problem. An appropriate description of the algorithms will help them in writing the right programs. The teacher has the strategic role of selecting algorithmic problems. He has to arrange them in ascending cognitive sequence.

The third step is to create a relevant logical model of the program task. At this stage, the new knowledge should be presented in small portions, supported by appropriate examples.

Figure 1. The training steps ascending order [11]
The analysis of the condition is essential here. The teacher explains that behind the words in the task description of each programming assignment, there is a logical model that they have to reach. The difficulty at this stage of learning is the building skills in the abstract thinking of students. Abstraction in programming appears to be at a higher level for young students. The teacher takes care of overcoming this problem by gradually increasing the level of abstraction. Answering the following questions helps students: What is there in the task description?, What is the required result in the task?, How could be obtained the result from the given data?

The next step in teaching informatics is to learn a programming language and the basic principles of programming. The proposed approach does not depend on the applied programming language.

Currently, the training focuses on the C++ language. The students have to master the syntax and semantics. They have to deal very well with the programming environment and the sequential steps to prepare a working program. The choice of the programming environment is determined by this, which is used in competitions in all age groups.

The teacher has the responsibility for learning a programming language to start in parallel with learning algorithms. This correlation helps the acquired algorithms to be programmed and immediately implemented and tested on a computer.

The teacher has an essential role in training future participants in informatics competitions to be able to detect and correct errors in their programs themselves. They have also to be able to assess the various possible solutions to a problem to choose the best option. For this reason, the last and most extensive step in the learning process is knowledge approbation and solution discussion.

C. Results

The new and different in the proposed approach for discovery, preparation, and development of gifted students in the field of informatics is the usage of didactic principles in determining the activities of the teacher and the division of work into stages. This definition ensures consistency in building skills and stability in the knowledge of competitors. There is a consistency in the results achieved by avoiding extreme loads and stress for the young students.

The proposed approach was developed, piloted, and implemented dynamically in a real learning process conducted in the School of Informatics at Center for Student, Technical and Scientific Creativity in the city Ruse. An important criterion for its qualities is the presentation of the students in the national computing competitions, in which they traditionally take prizes.

There are ten schools in Bulgaria for training competitors in informatics. The composition of the national team is formed by the first ten students in the maintained national rank list. They receive the right to participate in the National Campus of Informatics, organized under the auspices of the Ministry of Education and Science and the Union of Mathematicians in Bulgaria.

Table 1 presents the number of participants from Ruse in these camp schools.

There is a quota of four participants for each country for the international competitions European Junior Olympiad in Informatics (EJOI) and Junior Balkan Olympiad in Informatics – JBOI. Since 2016, 25% of the participants in the national team are from the school in Ruse [12].

III. CONCLUSION

There are different approaches to discovering, preparation and developing gifted students in the field of informatics. Unfortunately, programming is a wide-ranging area, often requiring complex intellectual efforts. Therefore, the organization of this type of training cannot be exposed in a condensed form as some pure "recipe training". Efficient success depends heavily on the teachers' activities in discovering and developing trainees. Teachers build up competitors' profiles - from his diligence and intuition to learning based on basic examples, from the creation of positive motivation, the rapid formation of lasting skills, and learning both for group work and self-study.

The results show that in the presence of ten schools, training in the proposed approach provides 25% of national competitors. The percentage of medals won by international competitions in the period 2017 - 2019 by competitors from the Ruse school compared to the total number of awards for Bulgaria is 16.67%. Our graduates have won 8 out of a total of 48 medals.

Each of the ten schools applies its approach to discovering, preparing, and developing of competitors in informatics. For this reason, the proposed approach cannot be compared with a similar one. Summaries about its effectiveness could be made from the results of the students.

The achievements of the competitors in informatics from Ruse prove the hypothesis that the application of the didactical principles in the learning process will give a chance of a teacher to increase the number of successful competitors.

Developing new approaches to training for beginner-child programming, verifying them in real-life conditions, and sharing experience gained to contribute to the successful realization of the tasks set out by the EU strategy.

The study of the role of the teacher in the discovery, preparation, and development of gifted students for competitions in informatics will be in-depth by detailing the teachers' actions in the selection of learning tasks and the evaluation of their solutions.

<table>
<thead>
<tr>
<th>Year</th>
<th>6 grade</th>
<th>7 grade</th>
</tr>
</thead>
<tbody>
<tr>
<td>2013</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>2014</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>2015</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>2016</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>2017</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>2018</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>
REFERENCES


[12] Web portal of the Team of Bulgarian Experts in Informatics, Available at: http://math.bas.bg/infos, [acessed: 15.05.2020]