Learning Scenarios and Encouraging Algorithmic Thinking

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***Abstract* - Although contemporary education places learners at the center of the teaching process, in most of our schools, students are mostly educated by traditional outdated teaching methods. Students should be active participants in the educational process that will, through research in collaboration with the teacher and other students, acquire new knowledge and develop various competencies, especially in the STEM field. The traditional role of the teacher, as the main source and knowledge transferor, is changing, so preparation for teaching should be adapted to such changes. Learning scenarios can contribute to the development of innovative ideas for the implementation of educational activities, including modern teaching methods using digital tools and digital contents. The Erasmus+ project "Games for Learning Algorithmic Thinking" begins with the education of primary school junior grade teachers, who will develop such learning scenarios and apply them with their students. The paper presents how the appropriate learning scenarios can stimulate the algorithmic thinking of young students in everyday situations.**

Keywords – learning scenario, algoritmic thinking, games and learning; primary schools teachers

I. INTRODUCTION

Instead of teaching facts, generalizations and content that was characteristic of the traditional school, in contemporary teaching based on the co-constructivist curriculum, emphasis is placed on active learning, affirmation of pupils' potential and the development of specific interests of each individual [27], [24]. Such a contemporary approach continues to reconsider the roles of the participants in the teaching process, placing students at the center of the educational process. There has been a lot of interest in changing the educational process itself, that is, to provide new teaching methods that can structure the learning task, guiding learners through the process of learning and helping them to understand and apply the acquired knowledge.

In the Croatian National Curriculum Framework for preschool education and general compulsory education in primary and secondary schools, explaining the advantages of the curricular concept, it is stated: "Living and working in a modern society of rapid change and sharp competition require a new type of knowledge, skills, values and attitudes, i.e. new competences of the individual, which emphasize the development of innovation, creativity, problem solving, development of critical thinking, entrepreneurship, computer literacy, social and other competences" [12]. Bearing in mind the demands of the time we live in, it is necessary to approach curriculum reforms following the context of global social and educational reforms.

Contemporary teaching approaches like project based learning, problem based learning, inquiry based learning, scenario based learning and reflective learning in teacher education have recently gained considerable attention. Most of the studies have been conducted with the aim of comparing the efficiency of contemporary teaching approaches with traditional methods. The use of technology in all sectors, particularly in education, requires teachers with certain digital competencies in order to use the teaching technology and make the learning process more interesting to students. Schelfhout et al. [26], emphasize that the most fundamental problem encountered during the learning-teaching process is that students memorize the new information and fail to convey what they have learned into new situations. European Schoolnet launched the European Coding Initiative for the promotion of teaching and learning programming and coding and stronger integration of coding in K12 education. Teachers are provided with support in the form of teaching materials, tools and lesson plans for informal learning. In a study on the level of the European Community, Gander et al. [11] point out that European citizens have become consumers of ready-made software products, and conclude that digital literacy (a set of basic skills) and computer science (research subject) are essential components of modern education. Under the influence of various trends, special emphasis has been placed on the development of algorithmic/computational thinking, which becomes one of the core competencies for the 21st Century [3]. According to the research in CARNet project "e-Schools: Establishing a System for Developing Digitally Mature Schools", schools in Croatia are on average placed under the category "digital beginners", where teachers are insufficiently using Information and communication technology (ICT) to improve teaching. Furthermore, learning to code is not sufficiently present in schools because it is considered that students find programming too difficult and uninteresting. The DigComp Framework pointed out that digital content creation represents one of the five major digital competence areas, which includes the competence of programming, described as "the ability to plan and develop a sequence of understandable instructions for a computing system to solve a given problem or perform a

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specific task." This area is mostly abandoned in primary schools, where students do not have the opportunity to learn programming or algorithmic thinking. Learning outcomes related to programming should be represented in various school subjects and integrated into the daily learning through different school subjects starting from the first day of school.

Within this context, teachers who are one of the most outstanding elements of education should possess skills of being able to implement contemporary approaches that would enable students to carry out active learning. Jakee [15], claims that active learning is a much more effective process than the process in which the teacher "spoon-feeds" students. It is the former process that students gain advanced thinking skills from. Therefore, the traditional teaching methods that are mainly based on an objectivist approach are considered unsatisfying. Contemporary education is based on research, exchange of information, teamwork, connecting different cognitions and applying knowledge and skills. Such a curriculum encourages critical thinking, self-conceptualizing conclusions, solving problems, creativity in approach and communication among students.

II. CONTEMPORARY LEARNING AND TEACHING METHODS

A. *Learning strategies toward active learning*

The founding of modernity in teaching activities is reflected in the interactive relationship between all the elements of the didactic-methodical field which are mutually conditioned. The effectiveness of teaching activities at all stages of the teaching process (preparation, implementation and evaluation) implies a modernity in approaches through the application of strategies, methods and techniques of teaching the workshop, project, bulk-research, self-research type of educational work. Creating teaching scenarios in the teaching process, as stated by Buljubašić & Petrović [4], is based on the features of new generations and new ways of communication, an accelerated and changing environment and on technological advances. In this context, there are numerous opportunities for the development and implementation of the teaching process as a partnership based on the maximum involvement of all participants and on mutual co-operation. Emphasis is put on student-centered learning, tailored to the needs of students.

Teaching activities oriented to discovering cognitions and the productive application of knowledge, provide access to the learning and teaching process, where students create, discover, independently plan, give the initiative, ask questions and investigate. Students are asked to understand, to express their own view of certain phenomena, to critically think, to build a creative approach for problem solving, and not just to reproduce content. "Students are especially encouraged to connect knowledge with personal experiences and knowledge, experiences of everyday life and with the knowledge of other subjects' areas" [2]. Teaching, besides explicit theoretical knowledge, should be focused on the process of gaining knowledge, i.e. on understanding of the process of research and discovery.

Therefore, it is necessary to apply teaching strategies which, according to Cindrić et al. [6] include "a thoughtful combination of methods and procedures that encourage the students' activity and enable him to manage his/her own learning process in order to achieve the goals of education." Marzano et al. [17] discuss learning strategies that affect students' achievements. They are differentiating between student-oriented strategies (e.g. summarizing, recording, nonlinguistic representations, cooperative learning, goal settings, creating and verifying hypotheses ...) and putting them into the context of conducting a research in instruction. The teaching methods as a combination of various methods, through which the learning process is structured in order to achieve predetermined goals that teachers and students apply in the educational process [18], should contribute to the individualization in teaching students and thereby respect the different learning styles of students. Fox & Hoffman [10] define individualization of teaching as a flexible, fair and intelligent approach to teaching and learning and use the terms "different assessments", "inclusion", "learner-centered teaching". Other authors conceptualize this term as "adaptive teaching" or "personalized learning" [32] and "unique learning design" [13]. Taking into consideration the specificities of students in the context of individualization of teaching, the use of various methods and teaching strategies is suggested which will lead to active learning. Active learning in the narrow sense of the word is defined as "learning that provides a high level of autonomy and self-control to students, as well as an application of various mental strategies and specific cognitive abilities for distinguishing important and unimportant information, analysis and comparison, knowledge acquisition based on previous experiences and critical thinking" [21]. As Slavin [29] points out, we are talking about collaborative learning methods for which research clearly suggests that they have significantly improved pupil achievements in most subjects and degrees. Students together plan, investigate, co-operate in order to help each other achieve the intended teaching goal. The aforementioned context of the contemporary teaching process determines according to Suprayogi & Valcke [30] the application of strategies, the diversity in learning activities, monitoring individual student needs and achieving learning outcomes. More attention is focused on the application of modern technology in the teaching process. As emphasized by Pejić Papak & Grubišić Krmpotić [20], technology in this sense is not the purpose for itself. Teaching will not be enriched by formal introduction of ICT-based teaching methods and forms without a critical reflection on the reasons for implementation, learning outcomes as well as a didactic modeling for the purpose of improving the teaching process.

B. *ICT in Education*

Information and communication technologies ensured an application of new opportunities in the educational process. Computer science education in primary or secondary schools has reached a significant deflection, changing its focus from ICT-oriented to

essential computer science concepts. In Croatia, computer science education as a school subject is usually named Informatics. At the very beginning, teaching Informatics started with teaching programming. Programming was a good way to convey a process of problem solving. Later on, the content of Informatics switched to the implementation of ICT, mostly assigned to "applied" Informatics. Mark Prensky stated that "The True 21st Century Literacy Is Programming" [23], but on the other hand, Dagiene and Stupuriene [7] allege that we should avoid 'the equation': computer science = programming, which is accused of killing interest in computer science among school students in 1990. Not all students will become professional programmers, but by writing their own programs, they practice creative and computational thinking, and gain skills of the digital era, which are useful for their professional and personal lives [7].

As technology has emerged in all school subjects, not only Computer science teachers are allowed to use it. Teachers of junior grade in primary school, who are one of the most outstanding elements of education, should possess skills of being able to implement contemporary approaches with or without technology that could enable students to carry out active learning. The results of the research [20] showed (N=220) that 80% of the junior grade teachers and 83.5% of the undergraduate students of the Teacher Study agree with the statement that "Using ICT is an indispensable part of teacher education". This provides a space for further use, development and implementation of modern technology in education. Active learning by using technology enables a faster realization of certain activities. However, teachers will be able to conduct effective teaching when they are fully equipped in their professions. Therefore, it is clear why teacher education is crucial in this sense [14].

III. THE ROLE OF LEARNING SCENARIOS IN MODERNIZING THE TEACHING PROCESS

Teaching has always involved some elements of 'design' in the process of preparation and planning. Classroom teaching with minimal equipment allows teachers to adjust their approach to the immediate needs of learners [1]. Teachers can, only by observing, quickly ascertain if learners are fulfilling their tasks, while they can also rearrange groups or reassign activities, give some additional explanations and ask questions to help learners understand and accomplish their tasks.

Despite afore mentioned, teachers have to plan or structure the learning situations in advance. The situation may be as small as a single task or as large as a whole course. In a learning situation, any of the following may be designed with a specific pedagogic intention: learning resources and materials; the learning environment; tools and equipment; learning activities; the learning programme or curriculum [1]. Student activities should be at the center of the design process, and they should be carefully aligned with the desired learning outcomes and with the processes of assessment and review. Learning scenarios are materials intended for teachers that offer innovative and imaginative ideas for conducting teaching activities using modern pedagogical methods with the use of appropriate digital content and tools [5]. Although it has been mentioned that Learning scenarios use digital content and tools, they can be created for other activities that do not use technology. It is useful to distinguish activities from tasks. In a formal educational setting, tasks are required from learners by the demands of the curriculum. Activities are engagement of learners in response to the demands of a task. [1]

Learning scenarios are designed to motivate students, to bring them closer to the content and to link the content of a teaching subject to everyday life situations. In addition, contemporary education strives for a stronger content integration of different school subjects. That is why the learning scenarios should have accentuated correlations with other teaching subjects, as well as designed activities in order to emphasize and encourage this connection. Designing a learning scenario is a process by which teachers plan or structure a learning situation. A scenario consists of a subject and class, a complexity level, key concepts, learning outcomes and a description of activities complemented with materials and resources for the teacher and students [5]. In line with the focus on activity, learning outcomes are typically expressed in the form learners will be able to /*verb*/ /*qualification*/ where the verb describes the kind of an activity that learners will undertake (e.g. describe, interpret) and the qualification describes the context, scope or method to be used. One of the key features of problem-based learning is the use of scenarios relating to the real life as a point of departure for the learning process [8]. The intention is to get the students associate the scenarios with real-life situations. The scenarios are considered to provide a meaningful context for the concepts and principles that will relate to future knowledge acquisition. Although good teachers will provide with a direction on how tasks should be carried out, and even determine students' activities, different learners may still have their own ways of continuing the activities.

IV. ALGORITMIC THINKING

Algorithmic thinking primarily develops solving various problems that reflect real issues, through in which the application of knowledge from other areas, especially science, mathematics and logical disciplines is necessary. In a broader sense, computational thinking includes many components of problem solving: Formulation and restatement of tasks; Data analysis; Decomposition; Modeling and simulation; Recognition of pattern solution components; Automation of decisions; Efficient use of resources; and Abstraction of decision process [7]. Algorithmic thinking skills are supported and enhanced by a number of dispositions or attitudes, which are essential dimensions of Informatics and digital literacy. The concept of Algorithmic thinking has been present since the 1950s and 1960s, referring specifically to using an ordered and precise sequence of steps to solve problems and (when appropriate) a computer to automate that process [31]. Today, it is often replaced with the term "computational thinking". Wing [33] defined computational thinking as "solving problems, designing systems, and understanding human behavior, by drawing on the concepts fundamental to computer science."

The cognitive aspects of algorithmic thinking involve the use of heuristics, a problem-solving approach that involves the application of a general rule of thumb or strategy that may lead to a solution [33]. This heuristic process involves searching for strategies that generally produce the right solution but do not always guarantee a solution to the problem. For example, "asking for directions in an unfamiliar place" from a local usually leads one to the right place, but one could also end up in a wrong place, depending on one's understanding of local geography [31]. Algorithmic thinking concepts have been used in other disciplines through problem-solving processes so it can be included in primary education. Wing [33] said, "we should add computational thinking to every child's analytical ability alongside to reading, writing, and arithmetic." Embedding computational thinking in teaching and learning junior grades of primary school requires teacher educators to prepare teachers to support students' understanding of algorithmic thinking concepts and their application to the disciplinary knowledge of each subject area. Specifically, teacher educators need to provide teachers with the content, pedagogy, and instructional strategies needed to incorporate computational thinking into their curricula and practice in meaningful ways, enabling their students to use its core concepts and dispositions to solve discipline-specific and interdisciplinary problems and to enhance existing learning outcomes.

When explaining a problem as algorithm, it is breaking down in smaller sections, more familiar, that can be solved using a set of rules (algorithms) to find solutions and using abstractions to generalize those solutions to similar problems" [33]. Algorithms are central to both computer science and computational thinking. Algorithms underlie the most basic tasks everyone engages in, from following a simple cooking recipe to providing complicated driving directions. Due to the fact that there is a general misconception that algorithms are used only to solve mathematical problems and are not applicable in other disciplines, [31] it is important to introduce students to algorithms by first using examples from their daily lives. For example, in early grades, teachers could highlight the steps involved in brushing teeth, while in later grades, students could engage in following steps during a lab experiment. However, according to Shelton [28], the development of algorithmic thinking in children at elementary school does not necessarily require the use of a computer, but can also be achieved with "unplugged" methods, which are not an alternative for using a computer but are to be used as an auxiliary activity in understanding and solving the problem. Understanding algorithms as a set of precise steps provides the basis for understanding the manners of the development of an algorithm that can be implemented in a computing program. Students can be exposed to the computational thinking concept of abstraction by creating models of real life [31]. Teachers can have a new role in the teaching process to assists a student, altering the learning task so the student can solve problems or accomplish tasks that would otherwise be out of reach. The teacher intervenes at the appropriate time for a specific student in the context that increases the student abilities for solving the task. For example, a teacher may help a child in a board game by reminding him/her of the rules or by suggesting strategic steps if the child is stuck [25]. As Karadag [16] points out, Game Based Learning (GBL) is generally effective in primary education because primary school learners are at an age when games are particularly efficient. During this period, they also experience difficulty in learning abstract concepts and procedures, requiring both entertaining methods and an active involvement in learning activities.

Algorithmic thinking can be developed through all school subjects for which appropriate teaching methods are needed either with or without technology. Today, there are many different ways in which young children can learn basic programming concepts e.g., educational computer games [22]. Any learning situation can be improved by incorporating such methods in an appropriate learning scenario.

V. THE GLAT PROJECT

Encouraged by thoughts to enhance the teaching skills of primary junior grade teachers, the Erasmus+ project "Games for Learning Algorithmic Thinking" (GLAT) was developed. The main goal of the project is to encourage the inclusion of coding and algorithmic thinking in teaching different subjects in lower grades of elementary school in a fun and attractive way. This project started on October 2, 2017, and will run until September 1, 2019. The project coordinator is the University of Rijeka - Department of Informatics (leader Nataša Hoić Božić, Ph.D.). The partners in the project are: The Faculty of Teacher Education, University of Rijeka, University of Tallinn (Estonia), The Faculty of Pedagogy of the University of Ljubljana (Slovenia), University of St. Cyril and Methodius in Skopje (Macedonia) and Southwest University "Neofit Rilski" in Blagoevgrad (Bulgaria). The most important activities of the project include the professional development of primary school teachers with various innovative teaching methods using information and communication technology. Special focus will be on using educational strategies of Game Based Learning (GBL) and gamification in order to foster creativity, logical thinking, and problem-solving skills. During the project teachers will be grouped in a focus group to participate in education, formulated according to a mixed e-learning model. The key part will be the three workshops to be held in Croatia while the online part of the education will take place through the e-learning system Moodle. The focus group teachers will use the expertise of the project team to apply new knowledge for the development of learning scenarios, and apply those learning scenarios in schools with their students.

The topic of the first workshop, which will be held on April 5 and 6, is Game- Based Learning (GBL) and unplugged activities. The participants will be introduced to the use of games in different school subjects and the conduction of unplugged activities in classroom. The emphasis is on the examples of learning scenarios and the accompanying materials for the implementation of the activities, while the participants will conceive such activities, create a learning scenario and perform it with their students. For this purpose a Learning Scenario Template was produced as shown at Figure 1.

Games for Learning Algorithmic Thinking

Predložak za izradu scenarija učenja i poučavanja

(Learning Scenario Template)

Naziv scenarija (Learning Scenario Title)		
Nastavni predmet/Razred (Course/ Grade)		
Ishodi učenja (Learning Outcomes)		
Cilj, zadaci i kratki opis aktivnosti (Aim, Tasks and Short Description of Activities)		
Ključni pojmovi (Keywords)		
Korelacija i interdisciplinarnost (Correlation and interdisciplinarity)		
Trajanje aktivnosti (Duration of Activities)		
Metode poučavanja (Teaching Methods)		
Oblici poučavanja (Teaching Forms)		
Potrebni alati (Tools)		
Materijali za nastavnike (Resources/materials for the Teacher)		
Materijali za učenike (Resources/materials for the Students)		
Razrada aktivnosti (Teching summary)	Motivacija – uvod u aktivnost (Motivation introduction)	Trajanje (Duration)
	Provedba aktivnosti (implementation)	
	Refleksija na provedenu aktivnost (Reflection and evaluation)	
Prilozi (Annexes)		

Figure 1. Learning Scenario template

One such activity can be spatial orientation or moving through the maze. While engaging in this activity as part of the Science lesson dealing with reviewing and practicing the concepts of left and right, up and down and back and forth, students will mark the route by placing appropriate arrows in the maze as shown on Figure 2.

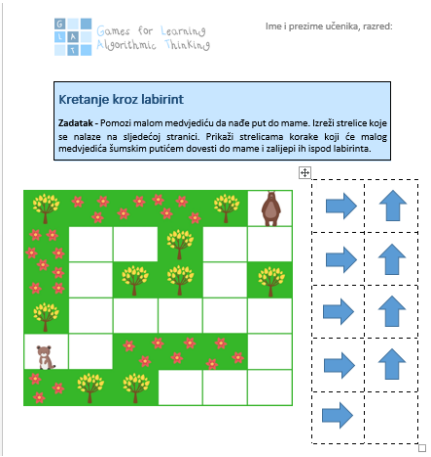

Figure 2. Example of the students' worksheet for unplugged activity "spatial orientation"

Furthermore, students will lead each other from the initial position to the final position in the classroom. Students will also get familiar with the concept of algorithm as a series of commands to be executed for achieving the task - arriving at the assigned location. Besides specifying the learning outcomes, aim, tasks and description of activities, the learning scenario includes a part for teaching summary. In this case, for the motivation part, the teacher can stand next to the door of the classroom and ask the students for help to get to the blackboard. The teacher can write his "path" on the blackboard stating the steps (commands) he has made. Other possible ways of getting from the door to the blackboard can be pointed out in the conversation with students, which brings a conclusion that the same task can be solved in several ways. The term algorithm is explained as a series of actions to be made in order to to accomplish a particular task. The implementation of activities include individual work, i.e. filling the worksheet (Fig.2), and team work in groups of four, where students lead each other in the maze made of desks and chairs in the classroom and write the algorithm of the movement. As a reflection on the conducted activity students are required to provide examples of simple tasks they do every day (getting dressed, washing, preparing school bags ...) and devise an algorithm for solving those tasks. The topic of the second workshop will be Problem Based Learning (PBL), online quizzes and logical tasks, while Games and Tools for Programming will be the topic of the third workshop.

Teacher and student feedback will be used to improve the designed e-learning course, and an improved version of the learning materials and the best examples of learning scenarios will be available as one of the projects results. The aforementioned materials will be published in Croatian and English, so teachers from across Europe can use them together with other Croatian teachers. The general goal of the project is the development of algorithmic thinking of younger students, which will improve students' attitudes towards coding and in the long term contribute to the reduction of the "fear" towards programming. In order to achieve this goal, it is necessary to develop students' digital content creation competence already from the first grade of primary school, and it can only be conducted by the teachers who have been trained for it.

VI. CONLUSION

The need for the introduction of coding and development of algorithmic thinking in schools has been already recognized in Europe. According to "Computing our future - Computer programming and coding - Priorities, School Curricula and Initiatives across Europe", some EU countries integrate coding in their curricula. It is mainly integrated at the secondary level and as a part of a computer science or informatics course or a separate subject but only for some school programmes. There are not enough appropriate subjects in studies for future primary school junior grade teachers, and especially not enough subjects within which the models such as Game Based Learning or the introduction to the elements of creating content and coding into teaching could be implemented. An integration of GBL scenarios in the teaching process can increase teachers' knowledge and skills and enhance their teaching practices.

The GLAT project will try, with contemporary methods and teaching strategies and through different school subjects, to implement the algorithmic way of thinking, problem-solving skills, logic and creativity into the daily learning.

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