

Problem Based Learning for Primary School Junior Grade Students Using Digital Tools

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Abstract - Problem based learning (PBL) is a learning strategy that uses a certain problem to encourage learners' critical thinking, information seeking, and finding solution for solving that problem. Such solutions are mostly identified in collaboration with other students. The role of the teacher is to develop innovative ideas for the implementation of PBL activities, using digital tools and digital contents. Learning scenarios as materials that offer such ideas can contribute in the involvement of young students in the process of PBL. The ongoing Erasmus+ project "GLAT-Games for Learning Algorithmic Thinking" involved 24 primary school junior grade teachers in education with different teaching strategies for stimulating the algorithmic thinking of their students in everyday situations. During the second workshop the participants were introduced to the use of digital tools for developing logical tasks and for the conduction of PBL. The set task for the participants was to conceive such activities, create a learning scenario of PBL and perform it with their students. After performing the activity in the classroom, a qualitative analysis of the preparation and implementation of the conceived activity was carried out. This paper presents a part of the analysis concerning the teachers' attitudes on the preparation of PBL activity using digital tools.

Keywords – problem based learning, logical tasks, digital tools, algorithmic thinking, primary school students

I. INTRODUCTION

The aim of contemporary teaching is to actively involve students in the learning process, thus expressing their creativity. This can be achieved by using modern approaches and teaching methods like Problem Based Learning. Solving a problem is very usual and important activity in everyday life as well as in professional work. The problem is most often associated with theoretical and practical difficulties that need to be overcome in an appropriate way. Contemporary teaching is based on the co-constructivist curriculum, where the emphasis is placed on active learning, recognition of students' potential and the development of specific interests of each individual [16], [13]. The Croatian National Curriculum Framework for preschool education and general compulsory education in primary and secondary schools was established in line with "The European framework of key competences for lifelong learning" where three out of eight lifelong competences point out "the ability of solving problem". In

the context of global social and educational reforms it is necessary to apply such teaching methods that can structure the learning task, guide learners through the process of learning and help them to understand and apply the acquired knowledge. Problem-solving skills and managing new information, as well as logical thinking and linking all aspects of knowledge, are the competences required by every individual and should be developed through the education system. Schelfhout et al. [15], 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.

Since Gagné pointed out that "the central point of education is to teach people to think, to use their rational powers, to become better problem solvers" [4], most psychologists and educators regard problem solving as the most important lifelong learning outcome. Ball and Forzani emphasize that the vision of better education includes an innovative use of technology, emphasizes group work, and integrated and problem teaching which should take place on the basis of a changed curricula and higher expectations of students [1]. There is no unique instructional design for the problem solving process, since there are differences among problems in terms of their structure, domain specificity (abstraction), and complexity [8]. Contemporary education is based on research, exchange of information, teamwork, connection between different cognitions and application of knowledge and skills. Such a curriculum encourages critical thinking, self-conceptualizing conclusions, problem solving, and a creativity in approach and communication among students. 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. Within this context, primary school teachers should possess skills to implement contemporary approaches and adapt them in order to enable young students to carry out active learning.

II. TEACHING WITH PROBLEM SOLVING

Teaching approaches like project based learning, problem based learning, inquiry based learning, scenario based learning and reflective learning in teacher education have gained considerable attention in the past decade in the area of teacher education [15]. The problem solving

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access to educational content is always in the function of enabling students to experience, understand and evaluate the content that is being studied. The student is the researcher and the creator, while the teacher is the organizer, the motivator and the facilitator [8], [9]. Most of the studies have been conducted with the aim of comparing the efficiency of contemporary teaching approaches with traditional methods [5], [10], [21]. Organization and teaching procedures should be chosen to maximize and sustain the student's thought activity and contribute to their conclusions and decision abilities. The organization of teaching with problem solving differs from the classical teaching, it is more in line with scientific research [18]:

- Creating a problem situation
- Formulating of the problem: finding an algorithm of the solution
- Hypothesis setting: selection of methods and forms of research
- Solving problems: verifying the hypothesis
- Analysis of research results that are followed by a conclusion and an application to new problem situations.

Vujičić, Pejić Papak and Valenčić Zuljan [22] emphasize that the key task of teachers in problem teaching is to provide conditions for the creative and research activity of students at all the above mentioned phases. M. Rijavec views teaching with problem solving from a psychological standpoint: "The main shift to the teacher's approach is from deductive thinking to inductive thinking. Instead of expounding the ideas and concepts, he has to take on a more passive role, and by applying Socrates's technique of conducting conversations, let students draw conclusions themselves and try to understand what they learn." [10]. 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. [2] include "a thoughtful combination of methods and procedures that encourage the student's activity and enable him to manage his/her own learning process in order to achieve the goals of education." Students are becoming more independent with the use of learning materials, while with the reflection on their work they are able to take on more and more responsibility for the obtained knowledge [5]. In order to implement creative problem-solving lessons, teachers use diverse methods of modern didactics and different forms of work, with a predominance of collaborative work and work in pairs, but sometimes, individual work, based on individualization and differentiation, is present as well.

Studies conducted in recent years have shown the advantages of collaborative problem-solving prior to the usual teaching methods to enhance students' conceptual understanding in mathematics and problem solving competency [17], but there are rarely found studies that adopt this approach in science learning in primary education. In collaborative problem solving for young learners, structured and guided approaches are recommended. Problem solving competency means engaging students in solving a problem using different

strategies, from multiple perspectives and with diverse modalities. Its processes include: exploring and understanding; representing and formulating; planning and executing; and monitoring and reflecting [12]. The research literature shows that project-based learning can help students enhance learning performance in knowledge advancement and skill development, and motivate them to learn [17].

Song also highlights the "productive-failure" as "a learning design that affords students opportunities to generate solutions to a novel problem that targets a concept they have not learned yet, followed by consolidation and knowledge assembly where they learn the targeted concept" [17]. This instructional design involves students first in unguided problem solving activities in order to evoke their prior knowledge, particularly the failure to solve the problem. Later students use this information to determine and assemble new knowledge after the teacher helps them solve misconceptions. This approach can be useful for young students to stimulate their active learning process. Active learning 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" [11]. The aforementioned context of the contemporary teaching process determines according to Suprayogi & Valcke [19] the application of strategies, the diversity in learning activities, monitoring individual student needs and achieving learning outcomes. Although many studies mention that active learning with problem solving should consider ill-structured problems, which will encourage critical thinking and evaluation of solutions [8], [14], it is better to start with well-structured problems with young learners. Novice learners need guidance to develop their problem solving skills, as well as self-directed learning skills. Furthermore, collaboration is yet another important factor in problem solving teaching in younger pupils because individual differences in prior knowledge and critical thinking encourage better achievements.

Nowadays, more attention is paid to the application of modern technology in the teaching process. As technology has emerged in all school subjects, not only Computer science teachers are allowed to use it. Digital tools ensured an application of new opportunities in the educational process. 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. [9] Therefore, it is clear why teacher education is crucial in this sense.

III. THE GLAT PROJECT

With the desire 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 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 is on using educational strategies of Game Based Learning (GBL) and gamification in order to foster creativity, logical thinking, and problem-solving skills. Primary school teachers were participating in education through three workshops and the online part with the e-learning system Moodle. The topic of the second workshop, held on August 2018, was Problem Based Learning (PBL), online quizzes and logical tasks. The emphasis was on the examples of learning scenarios and the accompanying materials for the implementation of problem based activities and logical tasks. This paper presents the results of the GLAT project after the second workshop. The focus group of teachers developed learning scenarios, and applied design activities in schools with their students.

A. Algorithmic thinking

Encouraging algorithmic thinking in younger students is one of the main goals of the project. Algorithmic thinking as part of computer thinking can be stimulated through a series of activities:

- Searching and sifting essential from non-essential data
- Summarizing and excluding items by attribute
- Comparison and classification of items
- Defining and describing a sequence of actions (algorithm)
- Detecting errors in the algorithm

Since our second workshop related to PBL, online quizzes and logical tasks, algorithmic thinking has played a major role in designing activities. When explaining a problem as algorithm, it is breaking down in smaller, more familiar sections, which can be solved using a set of rules (algorithms) to find solutions and using abstractions to generalize those solutions to similar problems [20]. For example, in early grades, teachers could highlight the steps involved in solving any problem thus explaining the algorithm. Algorithmic thinking can be developed through all school subjects for which appropriate teaching methods are needed either with or without technology. Any learning situation can be improved by incorporating such methods in an appropriate learning scenario from the first grade of primary school, and it can only be conducted by the teachers who have been trained for it.

B. Learning scenarios of PBL

The aim of each of our workshops was that teachers design and develop learning scenarios on the chosen topic of the existing curriculum using the principles of tools highlighted at the workshop. The planned activities should be carried out with their students.

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 [7], [9]. For the purpose of the second

workshop a Learning Scenario Example was produced as shown in Figure 1.



Predložak za izradu scenarija učenja i poučavanja (Learning Scenario Template)

Naziv scenarija (Learning Scenario Title)	Kulturne znamenitosti primorskih krajeva, obrada
Nastavni predmet/Razred (Course/ Grade)	Priroda i društvo, 4. razred
Ishodi učenja (Learning Outcomes)	<p>Opći ishodi učenja (General LO)</p> <ul style="list-style-type: none"> - Navesti kulturne znamenitosti i kulturnu baštinu primorskih krajeva - Istražiti posebnosti određene kulturne znamenitosti, kulturne baštine - Upoznati pučke običaje primorskog kraja <p>Specifični ishodi učenja usmjereni prema algoritamskom načinu razmišljanja (Specific LO oriented on algorithmic thinking)</p> <ul style="list-style-type: none"> - Pretražiti, pronaći i izdvojiti bitne od nebitnih informacija - Sažeti i izdvojiti elemente prema atributima - Usporediti i klasificirati kulturne znamenitosti i baštinu primorskih krajeva
Cilj, zadaci i kratki opis aktivnosti (Aim, Tasks and Short Description of Activities)	<p>Spoznati važnost i vrijednost kulturnih znamenitosti primorskog kraja. Pomoću kviza i igre memorije na računalu/tabletu usvojiti ključne pojmove te definirati problemsko pitanje za rad u skupinama.</p> <p>Problemskim učenjem istražiti posebnosti kulturnih znamenitosti (grupni rad na računalu), prezentirati prikupljene informacije na računalu te ponoviti nastavnu cjelinu na računalu rješavanjem interaktivnog radnog listića.</p>
Ključni pojmovi (Keywords)	Primorski kraj, kulturno-povijesni spomenici, pučki običaji (narodna baština)
Korelacija i interdisciplinarnost (Correlation and Interdisciplinarity)	Priroda i društvo, Hrvatski jezik, Likovna kultura i Informatika

Figure 1. Example of PBL learning scenario

The learning scenario should have accentuated correlations with other teaching subjects, as well as designed activities in order to emphasize and encourage this connection. As described in the example, the aim of this activity is to understand the importance and value of the cultural sights of the coastal region. The teacher will use a self-prepared quiz and a memory game on the computer/tablet for students to adopt key concepts and define a problem issue for group work. Via problem-based learning, students will explore the specifics of cultural sights (group work on a computer), present the collected information, and repeat the learning unit by solving an interactive worksheet on the computer. The applications used for conducting online quizzes and logical tasks were Kahoot! quiz, Match the Memory game, Wizer.me and LearningApps interactive worksheets.

During the November and December 2018, teachers implemented their conceived activities in the class and gave a reflection on the conducted activity. Reflection included performance considerations, whether performance required additional assistance to teachers, the number of students involved with the activity, how the students accepted the designed activities, whether all the learning outcomes stated in the learning scenario were realized and the possible changes in the scenario before the next implementation.

IV. TEACHERS' ATTITUDES TO THE PREPARATION OF PBL ACTIVITY USING DIGITAL TOOLS

At the beginning of January 2019, qualitative research was conducted through three focus groups with a total of 24 teachers. Each group consisted of eight teachers deployed per class, where they conducted problem teaching activities using digital tools (1st grade, 2nd grade, 3rd and 4th grade). The focus group method was selected as a preliminary survey of attitudes to education and improving personal competencies as a basis for the preparation of quantitative final evaluation of the entire project.

The aim of the research was to examine the teachers' opinions, attitudes and their personal experience in preparing for problem teaching with the help of the digital tools they had implemented with their students. The focus groups' implementation took place predominantly as a targeted conversation with pre-structured topics and subtopics on the competences of using digital tools in the process of teaching, preparation and implementation of problem based learning scenarios and using digital technology in the teaching process. Teachers expressed their attitudes and opinions through a conversation, describing their experience of problem based learning/teaching. The implementation of each focus group was audio recorded. Based on the obtained transcripts, the results were analyzed by systematizing the participants' answers to a particular question.

For the purpose of this paper the topic *Preparation and implementation of problem based learning scenarios* was analyzed through structured questions:

- How demanding is the preparation for this type of teaching and learning?
- How much time has been invested in developing the learning scenario?
- Do you estimate that your participation in GLAT education enhanced your teaching competences?
- Is the school well-equipped with technology?
- Was additional support of the IT teachers needed before the implementation of the designed scenario?

The systematization of the answers leads to the conclusion that design and writing of preparations for this kind of problem teaching is demanding, with which the group agrees. There has been a small polarization of attitudes in the opinion that the requirement for preparation is reflected only at the beginning of the application of this type of teaching. Here are some answers:

- "Preparation needed a recollection of everything we have learned through training"
- "I had to additionally test and try digital tools we used on the workshop"
- "I solved the doubts with the method of attempts and mistakes and successfully prepared the teaching scenarios"
- "On a scale from 1 to 10 I think the requirement of preparation is somewhere between 8 and 9"...

The group agrees that they have been using this kind of preparation for the first time, with an emphasis on the

outcomes and activities that will be achieved with the help of digital tools. They consider: "Any subsequent activity and learning scenario design will be much easier". "This form of preparation is extremely good regarding the direction of the curricular reform we are undergoing". The group concludes that the efforts they have invested in designing activities have resulted in showing interest in the more frequent implementation of the digital tools in teaching activities by students but also themselves in the context of innovation of the teaching process.

Due to the expressed demands of design activities, respondents were asked the question "How much time has been invested in making preparations/learning scenario for one lesson?" The group opinion is several days and stages in the process, because they encountered a new way of preparing lesson. The problem was not to elaborate the course of one lesson, but rather to envisage the time required for preparation of quizzes and logical tasks with digital tools and designing extra activities of the kind. Many teachers especially liked the Leplanner – graphical tool for creating a learning scenario.

The group also emphasizes the improvement of personal competency of teaching after the implementation of the learning scenario. Here are the highlighted answers:

- "The novelty of using digital tools in other subjects and not only informatics and I can do it"
- "The pupils are using computers and digital tools and they are not in the computer class and not with an IT teacher"
- "Students are showing their digital literacy through their work on the computers while the teacher directs it"
- "I am the creator and inventor of games, assignments and quizzes that I have never conducted before"
- "I can devise activities by organizing lessons on computers"
- "Such planned teaching can contribute to the thematic-integrated teaching"
- "The learning scenarios we have created can also be used in our subsequent work, as forms to be revised".

By systematizing the answers to the question: "Is school well equipped with technology?" a good equipment of computer classrooms was confirmed in all schools. The problems that the teachers point out about equipment are as follows:

- "There is only one computer classroom in school."
- "Access to an IT classroom is not always possible in scheduled time."
- "There is only one computer classroom that is permanently locked."
- "Classical classrooms should be equipped with a computer, projector and internet connection."
- "At least one tablet set to be used in parallel classes is required."

However, it is concluded that for all planned scenarios, all teachers managed to organize the classroom availability.

The polarization of attitudes was most apparent in the answers to the question: “Did you need additional help or collaboration with an IT teacher before the implementation of the activity?” The group did not have a common attitude. The most commonly expressed attitudes were:

- “I asked for the collaboration of the IT teacher to assist students during the implementation of activities in terms of typing keywords into a search engine or typing applications links, etc.”
- “I did not need any help from colleagues.”
- “I did ask for help from my colleague, but it was not adequately achieved.”
- “I think that I will be able to bring digital tools into the teaching process more independently with each subsequent activity implementation.”

V. CONCLUSION

There is not enough research related to the implementation of Problem Based Learning into teaching very young students. An integration of PBL scenarios in the teaching process can increase teachers’ knowledge and skills and enhance their teaching practices. Furthermore, such method can contribute to developing creativity and logical thinking in young students so they will be able to convey what they have learned in new situations. 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.

All teachers involved in focus groups emphasize the improvement of personal competency of teaching after the implementation of a learning scenario, as well as the novelty of the use of digital tools in other subjects, not only informatics. Finally, teachers point out that overall GLAT education will be useful to them in regard to the changes in the education system and the transition to a curricular approach, as the learning platforms are similar. They have regularly exchanged reflections on the forum and thus also learned. Teachers showed great satisfaction with the prepared scenarios and readiness for investing further efforts.

The learning scenarios are based on general and specific learning outcomes and activities that deliver the outcomes, and the greatest novelty is the use of digital teaching tools, as well as the high motivation of students for game and problem based learning. The results obtained through the focus group will be used to improve the training syllabus, which is one of the goals of the GLAT project. Teachers consider that additional educational cycles for primary school junior grade teachers about the learning scenarios and the use of educational technology and web tools should be carried out and that they should become part of a continuous lifelong training of primary school junior grade teachers.

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