Games for Learning Algorithmic Thinking – GLAT Project

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Abstract

The project „Games for Learning Algorithmic Thinking“ (GLAT) is funded by the Erasmus+ Programme of the European Union under the Key Action 2: Cooperation for innovation and the exchange of good practices (Action Type: Strategic Partnerships for school education). The coordinator is University of Rijeka, Department of Informatics and the project lasts until October 2019. Project consortium brings together European experts in the field of didactics of informatics, e-learning and programming from Croatia, Slovenia, Estonia, Macedonia and Bulgaria. The main objective of the project is encouraging the integration of coding and algorithmic thinking into the daily teaching through different subjects in students' younger ages in a fun and attractive way. 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.

This paper describes context and reasons for starting the project, planned activities and intellectual outputs as well as expected impact. The main project activities include professional development of primary junior grade teachers who will take part in workshops designed according to the blended model of e-learning.

Experts from partner organizations will help teachers to acquire the knowledge on using GBL in teaching the concepts of coding and algorithmic thinking and to use it for

developing learning scenarios. They will implement the learning scenarios in classes with their students. An important element will be a collection of teachers' and students' opinions through surveys and interviews which will be used as a feedback to improve the designed workshops.

Keywords: Project GLAT, algorithmic thinking, programming, didactic games, learning scenarios.

Introduction

Information and communication technologies (ICT) represent one of the fastest growing fields and the main generator of economic and society developments (European Commission, 2012). Nevertheless, learning outcomes related not only to ICT but also to the development of general digital competences are still insufficiently represented as part of curriculum in primary schools in Croatia and other European countries (Balanskat and Engelhardt, 2014).

According to The DigiComp Framework (Vuorikari *et al.*, 2016), digital content creation represents one of the five major 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 specific task". This area is particularly neglected in schools where students are not given enough opportunities to explore programming and learn algorithmic thinking and coding skills (Balanskat and Engelhardt, 2014). The learning outcomes related to the programming should be represented not only in school subjects directly related to information technology but also integrated into the daily learning through different school subjects starting already with the youngest age students, for example by using digital serious games.

One of the projects which deals with these concerns is *GLAT - Games for Learning Algorithmic Thinking*. The project is funded by the Erasmus+ Programme of the European Union under the Key Action 2: Cooperation for innovation and the exchange of good practices (Action Type: Strategic Partnerships for school education). The main objective of the GLAT project is encouraging the integration of coding and algorithmic thinking into the daily teaching through different subjects in students' younger ages (from first to fourth grade of primary school).

The project consortium brings together European experts in the field of didactics and methodic of informatics and computing, e-learning and innovative teaching methods who will work on the developing of training course for a group of Croatian teachers but it can be applied to all teachers across Europe. Project coordinator is University of Rijeka, Department of Informatics (Croatia), and the partners are: Faculty of Teacher Education University of Rijeka (Croatia), Tallinn University (Estonia), Faculty of Education, University of Ljubljana (Slovenia), Ss. Cyril and Methodius University in Skopje (Macedonia) and South-West University Neofit Rilski, Blagoevgrad (Bulgaria).

The project started in October 2017 and will last two years. The most important project activities will include professional development for teachers using three workshops where they will be introduced to innovative methods for teaching in the field

of ICT. The emphasis will be on algorithmic and computational way of thinking, problem-solving skills, logic and creativity integrated into the daily learning through different school subjects.

The main project results will consist of an enhanced syllabus of workshops with the materials for learning in Croatian and English language, complemented by the examples of best practices, and available at online platform for e-learning that will at the same time enable teachers the exchange of experiences and ideas on the application of innovative teaching methodologies. Syllabus will be used in the future for the organization of a program of professional development of teachers, course or similar forms of education in Croatia, partner countries and beyond.

The paper is organized as follows: the context and the importance of the research is described in the second section. Third section gives an overview of initiatives to encourage coding at a young age and highlights the need for education of teachers. Fourth section presents intellectual outputs of the GLAT project while fifth section describes workshops for teachers. Future plans and expected impact are described in the sixth section and the last section points out the main conclusions.

Context and the importance of research

One of the most important problem of the ICT industry is the lack of educational structures, and in the near future, the demand for IT occupations, especially those related to coding will grow even more. Therefore along with STEM (acronym for Science, Technology, Engineering, and Mathematics) related skills, greater efforts must now be made to highlight ICT as a priority area of education, and increase engagement at all levels (European Commission, 2012). This is in line with the "Europe 2020 targets" that are related to education and to reaching greater number of citizens completing the 3rd level education as well as to achieve increased employability (European Commission, 2010).

However, learning outcomes connected to ICT and to the development of general digital competences are still underrepresented as part of the school curriculum, especially in primary schools in Croatia as well as in other countries in Europe (Balanskat and Engelhardt, 2014).

According to the European Schoolnet research (European Schoolnet and University of Liège, 2012), the frequency of use of ICT equipment by students and teachers in Croatia is generally close to the EU averages but confidence in their ICT skills tend to be below EU averages. Newer European Schoolnet research „Computing our future - Computer programming and coding“ (Balanskat and Engelhardt, 2014) did not include Croatia (nor some other EU or European countries such as Slovenia, Macedonia) but it is known based on some other studies that schools in Croatia are in average placed under the category "digital beginners" in which teachers are insufficiently using ICT to improve teaching (European Commission, 2015), (Center for Applied Psychology Faculty of Humanities and Social Sciences in Rijeka, 2016).

In addition, despite some announcements that there will be changes regarding the status of informatics as a subject in schools within the curricular reform which preparation began in 2015, informatics is still only an elective subject in primary schools for students from 5th to 8th grade. Based on authors’ experience, learning to code is not sufficiently present in schools because it is considered that students find

coding too difficult and uninteresting. The development of computational and algorithmic thinking of students from first to fourth grade is also neglected and insufficient.

In the Proposal of National curriculum for the teaching subject of Computer Science/Informatics, one of the structural domains is Computational Thinking and Programming. This domain highlights the development of skills needed for logical and algorithmic thinking and application in different situations. The algorithmic way of thinking is primarily developed by solving various problems that reflect real-life problems and situations where it is necessary to apply knowledge from other areas, especially natural sciences, mathematics and logic ('Proposal of National curriculum for the teaching subject of Computer Science/Informatics', 2016).

The insufficient attention is also paid to the development of competences for the application of digital technology in education for future teachers. There is not enough appropriate subjects in studies that train future primary junior grade teachers in that field and as a start point, it should be enabled that teachers continue to improve their skills and knowledge in this area through a programme of lifelong learning, and in the future to incorporate the appropriate subjects as mandatory in the formal study programmes.

Review of initiatives to encourage coding and teacher education

The need for the introduction of coding and development of algorithmic thinking in schools has already been recognized in Europe. According to „Computing our future - Computer programming and coding - Priorities, school curricula and initiatives across Europe" (Balanskat and Engelhardt, 2014) some EU countries integrate coding in their curricula. It is mainly integrated at secondary level and as a part of a computer science or informatics course or separate subject but only for some school programmes. Therefore, across Europe the need for students' curiosity about coding, and building their confidence to pursue scientific careers already in primary school is recognized. Competitions that are offered in several European countries are one way of rewarding excellence in that area. Good examples are Hackathon on Coding (*All you need is {C<3DE}*, 2017) and Bebras (*The Bebras Computing Challenge*, 2018).

European Schoolnet launched the European Coding Initiative (*European Coding Initiative*, 2015) for the promotion of teaching and learning programming and coding and stronger integration of coding in K12 education. Teachers have also been supported directly in teaching programming and coding. Website for students, teachers and adults who want to try out coding for the first time have been built and open online courses have been conducted. These are for example All you need is {C<3DE} (*All you need is {C<3DE}*, 2014), Hour of Code (*Hour of Code*, 2015), Code Club (*Code club*, 2018). Also, collection and curation of teaching materials, tools and lessons plans has been carried out, for example on European Schoolnet Academy platform (*European Schoolnet Academy*, 2018).

These resources are intended primarily for informal learning and self-study with the possible help of online tutors. In addition, although it is stated that the resources can be used by anyone interested to learn programming, a high degree of motivation is needed in order to learn in such a way. From authors' experience, it is unlikely that they are suitable for primary junior grade teachers.

It has already been pointed out that not sufficient attention is being paid to the development of competences for the application of digital technology in education for future teachers in their formal education. There are not enough appropriate subjects in studies for future primary junior grade teachers, and especially not enough subjects within which models such as Game Based Learning or introducing elements of creating content and coding into teaching could be implemented. Even if there are such subjects present, they cover only a part of the competences and they are mainly elective. For example, at the Faculty of Teacher Education, University of Rijeka, one of the elective courses in the Graduate study of primary school education is "Extracurricular Informatics and Technical Activities". The situation is similar in most study programs for teachers across Europe which was one of the reasons for connecting partners from different EU countries.

Project objectives

The general goal of the GLAT project is improving students' attitudes towards coding and the development of algorithmic thinking of younger students, reducing the "fear" towards coding and increasing students' interest in the selection of future career in the ICT and STEM areas (in the long term). This will be achieved by professional training of teachers regarding the use of innovative teaching methodologies such as Game Based Learning (GBL).

The main objectives of the project are:

- Encouraging the integration of algorithmic thinking into the daily teaching through different subjects from the first to fourth grade of primary school.
- Training of teachers including the acquisition of contemporary knowledge and skills connected to different ICT related innovative teaching methodologies such as Problem Based Learning (PBL), Inquiry Based Learning (IBL), Game Based Learning (GBL).
- Creating blended learning e-course in LMS (syllabus, materials in English and (partly) in Croatian) for further using in the partner countries and beyond.

The GLAT project is innovative as its results can be used for informal, non-formal and formal learning. The project is not focused only on informal learning but also on non-formal learning and professional development of primary junior grade teacher with the aim to train them for introducing the concepts of coding, algorithmic and computational thinking to the primary junior grade students. It is believed that these teachers have no additional prior knowledge which is needed in order to introduce the before mentioned elements.

Syllabus with the materials for learning and with the examples of good practice and learning scenarios that will be developed by teachers will be available for self-study but it will also be available online for download and customize by all institutions (in Croatia, partner countries and across Europe) in order to develop non-formal lifelong learning programs based on blended e-learning model. The f2f part of these programs is particularly important in order to increase the motivation of the participants and facilitate the exchange of good practice among lecturers and other colleagues. It will also be possible to use the program modules to design courses and implement them as elective or mandatory in the formal primary junior grade teacher education or study programs of institutions that educate future teachers.

Intellectual outputs of GLAT project

The project consortium was set up to ensure effective cooperation and the joint work of experts in order to achieve the objectives of the project and to get high quality outputs. Three intellectual outputs are planned: O1 – Workshop syllabus and materials, O2 – Learning scenarios and O3 – The final version of the syllabus and learning materials.

O1 - Workshop syllabus and materials

Partners of the GLAT project will develop a syllabus and learning materials for 3-day workshops for focus group of teachers for f2f part of a total of 48 hours. The learning outcomes that relate to innovative teaching methodologies in the ICT area such as Problem Based Learning, Inquiry Based Learning, Game Based Learning will be defined. Special attention will be devoted to learning with the help of digital didactic games (serious games) and application of Game Based Learning and gamification.

In addition to the list of teaching topics, the syllabus will include the objectives of the course and elaborate learning outcomes and teaching strategies as well as selected teaching methods and activities which will be realized by the participants of the workshops (including individual and collaborative strategies). The tasks for the participants, with special focus on the development of the learning scenarios and preparations for teaching in a digital form will be planned. The participants will begin to develop learning scenarios and preparations for teaching at the workshops and continue to work on them individually. Content of the workshops, teaching topics in the form of presentations for f2f part of workshops and supporting material containing descriptions, examples and selected tools (e.g. tools for making games, web 2.0 collaboration tools, preparation of multimedia content) will be carefully chosen and prepared based on the learning outcomes. All materials will be published as an e-course in a Learning Management System (LMS).

O2 - Learning scenarios

Learning scenarios include documents in which the teacher develops innovative ideas to carry out educational activities by means of modern teaching methods with the use of appropriate digital content and tools. The most important elements of the scenarios are the description of activities and learning outcomes that are realized by the given activity as well as methods and digital tools used for their realization. Learning scenarios can be incorporated into the teaching of each subject in whole or as a part of a lesson (CARNet, 2017).

Tools that enable graphical representation of scenario elements facilitate the process of creating learning scenarios. One of these graphical tools is LePlanner (TLU School of Digital Technologies, 2018) that was developed at the Tallinn University for the project Creative Classroom (Hoic-Bozic *et al.*, 2016).

When creating learning scenarios within GLAT project, the main goal will be to encourage algorithmic and computational thinking of students as preparation for later learning of coding. The student will be in the centre of the teaching process and she/he will be encouraged to explore, think, reason and act. Learning scenarios are going to be designed in the way that students will become familiar with the teaching content, which

will be related to the situations from everyday life and are integrated into different school subjects. As the prevailing teaching strategy GBL, elements of PBL, IBL and other strategies that teachers will get familiar with at the workshops will be used. Since the ICT equipment vary in different schools, although the emphasis will be on using digital tools, attention will also be paid to those scenarios that will not use the technology and the examples. For example, games that take place in the classroom without using a computer, the so-called unplugged activities (Tsarava *et al.*, 2017), will be presented.

Teachers gathered in a focus group will start designing their learning scenarios which will include ways in which activities that promote algorithmic way of thinking and are related to coding could be included in different subjects. They will be able to decide independently which subject to choose, which lesson within the subject, which methodology and activities they will use and whether they will use ICT (computer, tablets, ...) in conducting the activities or not. During the workshop, experts will guide them and assist them in defining the initial ideas, but later after the workshop, they will continue to work independently. Online mentoring by experts and sharing ideas and tips with other colleagues will be provided through the communication channels available in LMS e-course. The final versions of scenarios will be tested in classrooms with the students.

O3 – The final version of the syllabus and learning materials

The last output of the project is related to the evaluation of the results of the workshops and learning scenarios in order to get the final result, which consists of an enhanced syllabus of workshops with the materials for learning complemented by the examples of best practices (among 60 learning scenarios the best ones will be chosen and translated into English).

While modifying syllabus, the experience of the experts gained during the workshops with the focus groups and during the process of reviewing learning scenarios as well as the opinions given by teachers and students through surveys and interviews will be taken into consideration. Although the evaluation of the workshops will take place immediately at the end of each f2f workshop, it is necessary to conduct a comprehensive research after the completion of all workshops. Psychologists in the Faculty of Teacher Education team will prepare questionnaires and interview questions that will check not only the satisfaction of teachers with the education, but also to collect suggestions for its improvement. The questionnaire will also be prepared for students who took part in testing of the learning scenarios.

Syllabus with supporting materials will be prepared in Croatian and English and it will be available to all interested parties through an online platform for e-learning even after the completion of the project.

Workshops for teachers

The most important activities of the project include professional training of teachers, who will be introduced to different innovative teaching methodologies that include the use of information and communication technologies, and the emphasis will be on using educational strategies of Game Based Learning and gamification in order to foster creativity, logical thinking, and problem-solving skills.

During the project, teachers will be gathered in the focus group to participate in education designed according to the blended model of e-learning. The key part will be three two-day workshops (three modules) that will be held in Croatia at the Department of Informatics, University of Rijeka, while online part of the education will take place using a learning management system. The learning management system MoD which is based on the Moodle platform was selected and the e-course "Games for Learning Algorithmic Thinking" was created (Figure 1).

The focus group includes 24 primary junior grade teachers from Croatia who are selected by the Faculty of Teacher Education with the help of Education and Teacher Training Agency (AZOO). Participation in the workshops will represent a form of professional development for teachers. Members of the focus group will meet three times in the two-day workshops. Dates of the workshops are in the periods of school holidays for students when professional developments of teachers usually take place.

The experts from partner organizations will lead teachers through a programme introducing them first in the area through theoretical topics, and continuing by showing examples, games, and appropriate tools. With the help of experts and based on acquired knowledge and skills, teachers will start with designing learning scenarios and preparations for lessons in digital format, which will include covered methodologies of learning and digital resources.

Topics of the three workshops/modules are:

1. Game based learning and unplugged activities
2. Problem based learning, online quizzes and logical tasks
3. Games and tools for learning programming

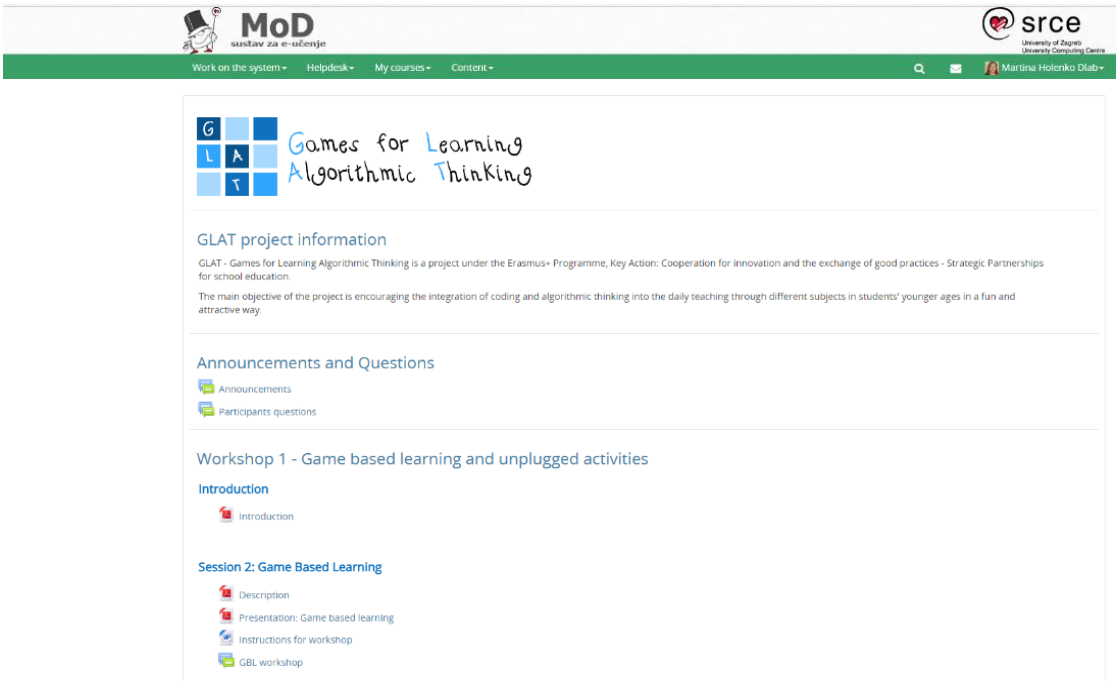

Figure 1 – E-course "Games for Learning algorithmic Thinking" in MoD LMS

First workshop

Workshop "Game based learning and unplugged activities" was held at the Department of Informatics, University of Rijeka, on 5th and 6th of April 2018. A focus group of 24 junior grade teachers participated in the workshop (Figure 2).

The main learning outcomes of this workshop were:

- describe principles of Game Based Learning,
- use Web 2.0 tools for creating content for unplugged activities,
- create learning scenarios in order to develop innovative ideas for carrying out unplugged activities.

Teachers attended lectures during which they were introduced to the concepts of Game Based Learning and unplugged activities. They also participated in individual and group activities, and analyzed examples of games and unplugged activities for different school subjects.

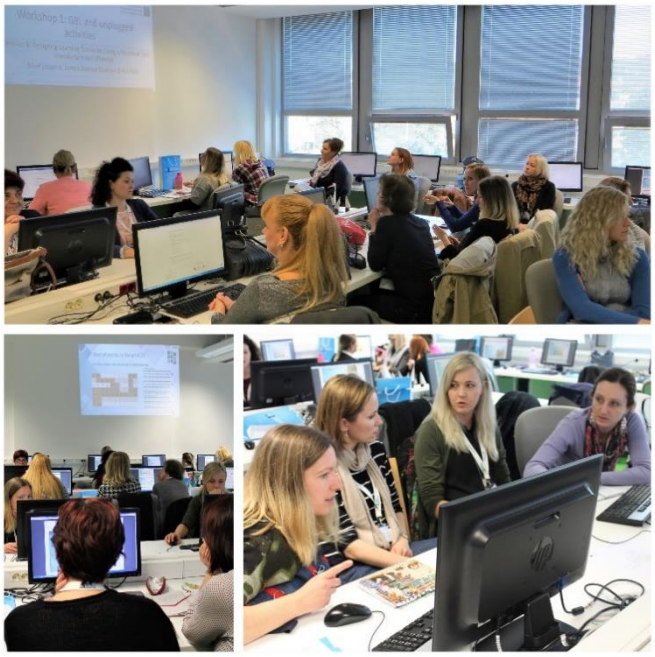

Figure 2 – Participants during the first GLAT workshop

There were several practical sessions where teachers had the opportunity to get to know and try out the learning scenario authoring tool LePlanner (Figure 3) and Web 2.0 tools Canva and Sketchpad for creating materials for unplugged activities.

At the end of the workshop, they started to apply newly acquired knowledge through the development of their own learning scenarios. Their task was to design a learning scenario for a selected subject (e.g. mathematics, nature and society, Croatian) that will include games and unplugged activities which will encourage students' creativity, logical thinking, and problem-solving skills. During learning scenario development, teachers could independently choose school subject and lesson within the subject as well as methodology and activities that promote algorithmic way of thinking and are related to coding.

Second workshop

The topic of the second workshop will be “Problem based learning, online quizzes and logical tasks” and the workshop will take place at the end of August 2018.

The main learning outcomes of the second workshop are:

- describe principles of Problem Based Learning and teamwork,
- use Web 2.0 tools for creating logical tasks and online quizzes,
- apply digital didactic games into different school subjects,
- create learning scenarios in order to develop innovative ideas for carrying out logical tasks and online quizzes.

In order to achieve learning outcomes, teachers from the focus group will be introduced to the concepts of Problem Based Learning, teamwork, digital literacy and digital content creation, online quizzes and logical tasks.

Practical part will include exploring the existing examples of games for different school subjects as well as activities like finding the appropriate period for implementation of the games within the lessons, deliberating how to match games with the learning outcomes and evaluating the existing games using the serious games evaluation framework. The participant will also have opportunity to work with digital tools that enhance the process of problem solving and Web 2.0 tools for creating online quizzes and logical tasks.

During the second workshop, teachers will start developing the first version of the second learning scenario that will include problem based learning activities, online quizzes and logical tasks.

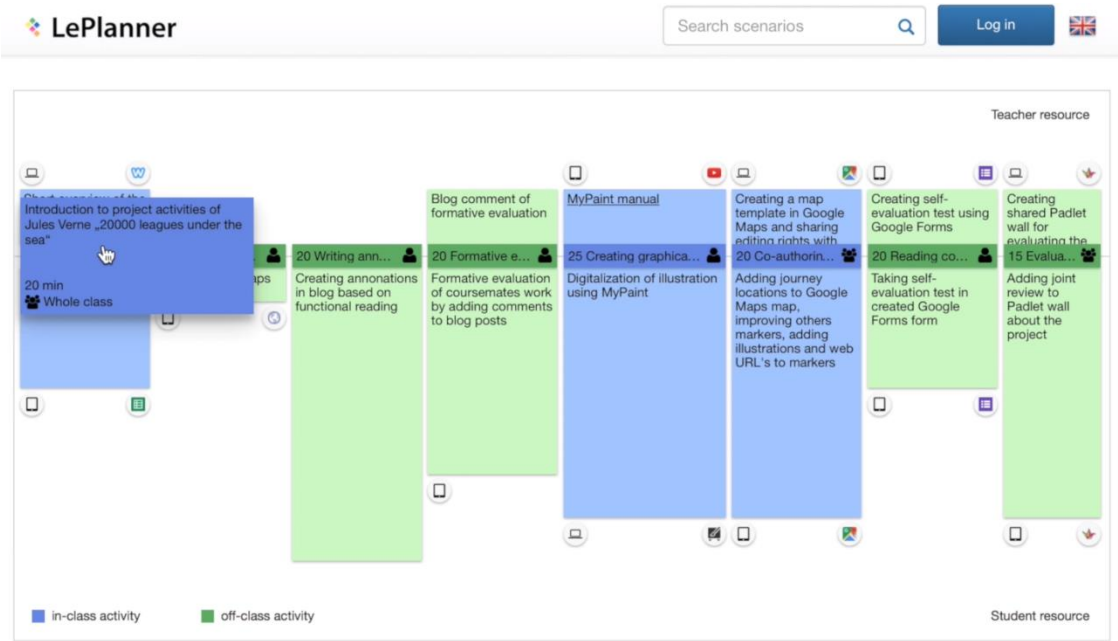

Figure 3 – Example of learning scenario created with LePlanner

Third workshop

The topic of the third workshop that will take place in January 2019 will be “Games and tools for programming”.

The main learning outcomes of the third workshop are:

- describe principles of Inquiry Based Learning,
- understand basic concepts of programming,
- create simple programmes (e.g. with ScratchJr),
- create learning scenarios in order to develop innovative ideas for applying programming concepts through game-based tools.

In accordance with the above listed learning outcomes, workshop participants will acquire elementary knowledge about the Inquiry based learning. They will also learn basic programming concepts (algorithms, sequence of instructions, conditional sentence, loop, variable) and will be introduced to games and tools for programming.

Throughout the practical sessions, teachers will be exploring existing games and tools like playing robot turtles, ScratchJr, and Micro:bits. They will also have chance to explore physical computing with Sphero SPRK+.

During the third workshop, teachers will start developing the first version of the third learning scenario that will include inquiry based learning activities, board games and other activities for applying programming concepts.

Future plans and expected impact

Currently, project team members are evaluating learning scenarios that teachers created after the first workshop. Based on the feedback from the experts, teachers will create improved versions of scenarios and then test them in classrooms with their students. In addition, project team members are working on learning materials and activities for participants that will be conducted during the second workshop. All designed learning materials will be available within the e-course in the MoD LMS.

During the project, a series of activities for the dissemination and popularization of results will be continuously carried out in all participating countries, including the final video conference where project's outputs will be addressed to teachers and all relevant stakeholders in partner countries. With the aim of informing on the project and its results, website glat.uniri.hr (Figure 4) was designed (*GLAT project website*, 2018). The web site and the e-course will remain available for further use after the completion of the project.

It is expected that the project will have an impact not only on the direct participants, but also on a much broader audience. The direct participants - primary school junior grade teachers gathered in the focus group will gain valuable experience by participating in the workshops and the development of learning scenarios together with European experts who will share their expertise and practices. The project is directed towards all other teachers as well because the results of the project will be presented in all partner countries, and developed learning materials with examples of good practice will be available to teachers to improve their competences and acquire contemporary knowledge and skills aimed at innovative teaching in the field of ICT and coding.

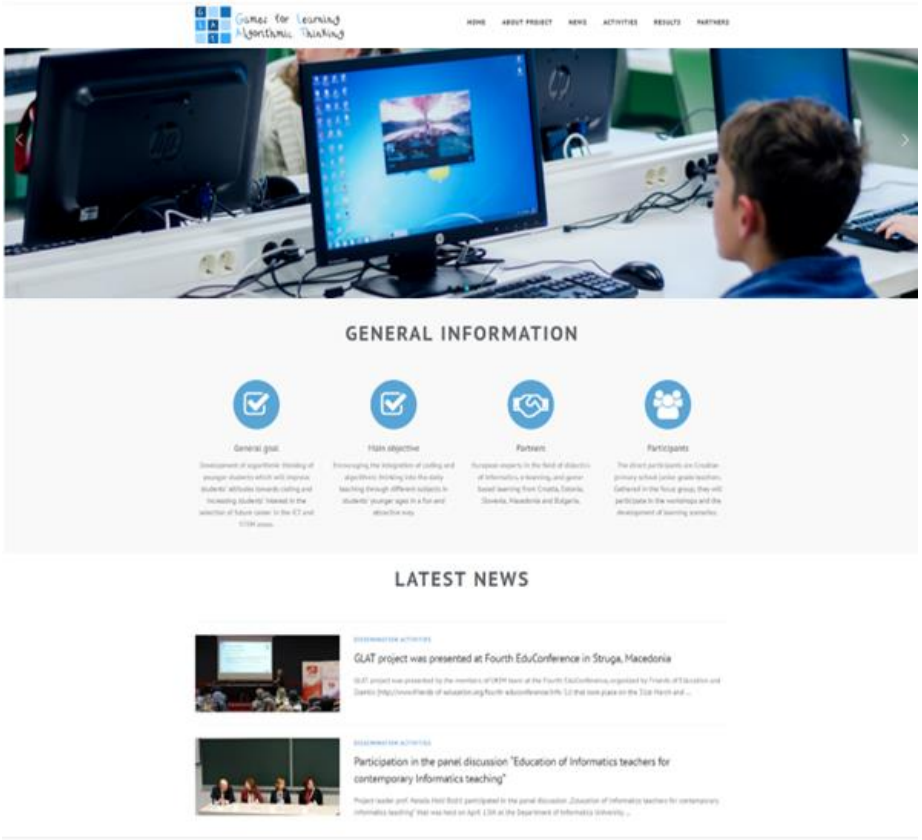

Figure 4 – Website glat.uniri.hr

Besides informal self-learning, after the completion of the project, the plans for the future include the accreditation of the program of lifelong learning for primary school junior grade teachers as a form of non-formal education at the University of Rijeka, organized by Faculty of Teacher Education and in cooperation with the Department of Informatics, University of Rijeka. The program will allow the strengthening of teachers' profession and improve teachers' competences. Finally, the project results will be used in formal education as a complement to the curricula at the Faculty of Teacher Education and to the mandatory and/or elective courses at the teaching oriented graduate study program at the Department of Informatics. In that way, the project will have an impact on the students - future teachers, as well. The project results will be readily available to use for informal learning in the partner countries and beyond because they will be translated into English, and in the future, it will be possible to organize and accredit appropriate forms of non-formal and/or formal education in a similar manner as in Croatia. It is expected that teachers will show interest in attending new training programs.

The impact of the project on students will be directly reflected in schools where new scenarios of learning will be implemented by the teachers who make up the focus group. In that way students will get the opportunities to explore and learn algorithmic thinking and coding skills from an early age through GBL and other modern teaching approaches. The future expansion of the impact of the project results to a larger group of teachers and students is expected. It will also result in a general improvement of students' attitudes towards programming and the development of algorithmic and computational thinking of younger age students, which will have a long-term impact

on the increase of their interest in the selection of future occupations in ICT and STEM fields. In this way, all involved partners who perform study programs in Informatics and Computer Science as well as all other higher education institutions that educate these profiles will gain direct benefit since it will enable the enrolment of higher number of quality students.

Conclusions

The GLAT project provides students and teachers with the support for the acquiring of relevant and high-quality digital skills and competencies in order to foster employability, socio-educational and professional development.

Among primary school teachers a training program, which promotes innovative methods and pedagogical approaches for the introduction of the teaching concepts related to coding and those that encourage the development of algorithmic thinking of younger students, will be implemented. The training also provides support for efficient use of ICT in education. Besides, materials for learning with the examples of best practices are being developed and activities for the dissemination and popularization of the results will be carried out. Teachers will promote the acquired skills and competencies among their students through teaching in primary schools and as a result students' digital competencies will also develop. Creativity, algorithmic thinking and problem solving skills will be encouraged already from the first grade of primary school in a fun and attractive way using didactical games.

The project team believes that the results of this project will contribute to the field of education supported by ICT technologies in Croatia, partner countries and beyond. The final goal of the project is the development of algorithmic thinking of younger students and improvement of students' attitudes towards coding. In the long term, it will contribute to reducing the "fear" towards programming and to increasing students' interest in the selection of future career in the ICT and STEM areas.

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