DEVELOPMENT OF COMPUTATIONAL THINKING SKILLS IN PRIMARY SCHOOL THROUGH DIGITAL STORYTELLING WITH SCRATCH

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Abstract: *Digital storytelling is a process of telling multimedia stories that can be interactive and contain game elements like labyrinths, sorting games, or puzzles. By combining the steps of the traditional storytelling process, creating multimedia, and defining game elements, teachers can encourage their students to acquire many fundamental skills including computational thinking. As a tool for both digital storytelling and computational thinking development, teachers may use a visual programming language Scratch. This paper presents a model for educating primary junior grade school teachers to use digital storytelling with Scratch for achieving learning outcomes of different school subjects as well as for the development of computational thinking skills of their students. The model is included in the blended learning course developed within the Erasmus+ project GLAT (Games for Learning Algorithmic Thinking). The paper brings experiences about educating the teachers enrolled in the GLAT course and engaged in designing interactive Scratch stories.*

Keywords: *Digital storytelling, Scratch, educational games, GLAT project*

1. INTRODUCTION

Digital storytelling has been recognized as effective way for achieving learning outcomes of different school subjects [1]. It is a process of telling stories by integrating multimedia elements (images, sound, text, animation) using digital tools [2]. By engaging in the process of designing and creating digital stories, students can develop computational thinking skills as well as many other skills such as research, organization, digital literacy, and problem solving skills [3].

The process of computational thinking involves formulating a problem and expressing its solution in a way that a human or a machine can effectively perform [4]. Among fundamental skills needed for that process are [5]: decomposition, abstraction, algorithms, debugging, iteration and generalization. These skills are used to break the problem into smaller parts, logically organize and analyse data, identify and apply existing solutions in order to design efficient solution of the problem, etc. [2]. Computational thinking skills are related to programming skills since some programming techniques are used in the problem solving process. In addition, computational thinking skills are needed to implement the develo─ped solution of the problem using a computer [6]. Computational thinking skills should be encouraged from primary school [7] because these skills are useful for a career in many sectors (e.g. education, healthcare, tourism, business and financial markets) [5].

To motivate students to engage in learning activities that support the development of computational thinking skills, teacher can combine digital storytelling activities with Game Based Learning [1], [7]. Since most of today's students are fond of digital games, they find activities that include playing or designing games very interesting. These activities can also support the learning of basic programming concepts and motivate students to start using programming languages appropriate to their age (i.e. visual programming languages like Scratch) [2].

One of the project that tends to promote development of computational and algorithmic thinking using games is Erasmus+ project GLAT (Games for Learning Algorithmic Thinking) [8], [9]. This paper present a model for educating primary junior grade school teachers to use digital storytelling with Scratch for achieving learning outcomes of different school subjects as well as for the development of computational thinking skills of their students. The model is included in the blended learning course developed within the GLAT project. The paper also brings experiences about educating the teachers enrolled in the GLAT course and engaged in designing interactive Scratch stories and gives overview of the outstanding digital stories created during the project.

2. DIGITAL STORYTELLING

By combining the steps of the traditional storytelling process with gathering and creating digital media, teachers can encourage their students to become creative narrators, enable them to acquire many generic skills, as well as to achieve specific learning outcomes of different school subjects [1], [3]. For example, students can illustrate events from their lives or a plot of a favourite fairy tale [2].

Key elements of the digital story are [3]:

- setting of the story,
- characters,
- scenes,
- sequence of events,
- narrative perspective (point of view).

To make stories interactive, students can add game elements or challenges like mazes, brain teasers, sorting games and puzzles that should be solved by the player [10]. Mentioned games enable the player to develop computational thinking skills [11]. For example, after researching about cultural sights of their region, students can present them using a story and design games in which the player should demonstrate the knowledge of these sights. Students can also illustrate a real life mathematical problem and design logical games combined with mathematical tasks in which the player needs to apply knowledge to achieve the goal of the game.

As shown in Image 1, the teacher can start the digital storytelling process by selecting a topic and, with the help of students, formulate the initial ideas about the story and define its purpose and target audience. The teacher then guides students in exploring the topic and gathering necessary information. In this step students construct knowledge and organize ideas [3].

Students should decide regarding appearance, personality traits, and motivations of characters, describe the setting of the story (time and place), formulate the problem faced by the characters, how it is approached, and about its outcome. They should also design game elements - challenges that should be solved by the player (the playing character) [10]. Besides the player, stories can have narrator, a non-playing character who guides the player through the game and gives instructions and feedback, as well as other non-playing characters [3].

In the next step a script should be defined. An initial ideas need to be further developed and text that will be shown or told by characters prepared. Teacher should help the students to write interesting but focused and concise story that it is easy to understand. Before actual work on creating the digital story using the chosen tool, the storyboard is usually created. It is a written or graphical representation of all the elements that will be a part of the story including media files (images, text, narration, music) [3].

Interactive digital stories with game element can be created using visual programming languages like Scratch which offers a library with numerous sprites (characters), backgrounds, and sounds [2]. While designing and creating

Image 1: Digital storytelling process [3]

interactive stories with game elements, students have the chance to develop their computational thinking skills since they [2]:

- formulate a problem – students determine which elements should be used,
- logically organize and analyse data – students create characters, scenes and sequencing by building blocks of code,
- represent the data – students tell the story by defining movement of characters and dialogs among them, define variables for collecting points and timers,
- identify, analyse, and implement solutions – students ensure that the program works as intended, in the ordered steps.

After combining all elements together and sharing the created story with others, the final step of the process is gathering feedback and reflection [3].

3. PROMOTING DIGITAL STORYTELLING WITHIN THE GLAT PROJECT

During the GLAT project [8], a professional development training was organized for primary junior grade teachers to encourage the integration of activities for development of computational thinking skills into the daily teaching of different subjects (from the first to fourth grade of primary school).

GLAT training for primary junior grade teachers

The participants of the training were Croatian primary junior grade teachers. They attended a blended e-learning [12] training course where three face-to-face workshops were combined with online mentoring in a learning management system. During the training, teachers were introduced to innovative teaching strategies including Game Based Learning (GBL), Problem Based Learning (PBL), and Inquiry Based Learning (IBL) [11]. Besides theoretical topics, examples of games and digital tools that can be used for development of computational thinking were presented and analysed.

The following three two-day workshops were organized:

1. GBL and unplugged activities,
2. PBL, online quizzes and logical tasks,
3. IBL, games and tools for learning programming.

After each workshop, teachers applied acquired knowledge and skills and, with the help of experts from the project team, developed learning scenarios (i.e. preparations for classes in digital form [13]) for different school subjects. Learning scenarios developed by teachers included educational activities for development of algorithmic and computational thinking in line with workshop topic and presented teaching method. Teachers implemented all developed learning scenarios in classes with their students.

Introduction of digital storytelling

Digital storytelling was introduced during the third GLAT workshop so teachers planned activities related to digital storytelling in their learning scenarios. Image 2 shows the sequence of activities performed by the teachers, their students, and university students after the third GLAT workshop. The teachers first developed learning scenarios for the chosen school subject and topic. They included the activity of designing the digital story with game elements as well as IBL activities. Then, teachers developed initial ideas for digital stories related to the chosen topic. In the next phase, the teachers implemented the designed scenarios in the classroom with their students. After a set of activities designed in line with IBL (and other strategies), all the teachers planned the following activities: designing interactive story with game elements, viewing/playing the designed story with game elements, and reflection.

The teachers guided students through the process of designing the story with game elements. They described the setting of the story and decided on names and appearances of characters (playing characters and characters who guide the player through the game and give instructions and feedback). After exploring the topic and gathering necessary information, students also designed game elements that enable the player to develop algorithmic thinking skills (e.g. challenges like labyrinths, brainteasers, sorting games, and puzzles). The students were also included in defining scenes, the sequence of events, and logical conditions for directing the flow of the game.

In the process of designing digital stories with game elements, the students could learn basic programming concepts [2], [14]:

- sequence – students arrange the elements in the chronological order in which they will appear in the story
- data – students define which data need to be stored (e.g. player's name, collected points, remaining time, etc.)
- condition – students direct the story flow, define how the player will collect points, define the end of the game, etc.
- loop – students define challenges for the player, decide how many attempts the player will have to finish the game, etc.

Visual programming language Scratch [15] has been chosen for creating designed digital stories. The participants of the GLAT workshops were junior grade teachers and non-informatics teachers who did not have enough knowledge and skills to independently code in Scratch. Therefore, in the preparation of the stories with game elements university students - future teachers of informatics, helped the teachers. They programmed the stories according to the instructions provided by the teachers and their students. The Table 1 shows outstanding digital stories that were created during this very successful collaboration.

Reflection on the development and implementation of learning scenarios

Most of the learning scenarios developed by teachers were for the Science course and the other scenarios were for Mathematics and Croatian language. After the implementation of learning scenarios in the classroom, a reflection was performed.

During reflection, teachers expressed their comments regarding implementation, how the students accepted the designed activities (especially the parts about designing the game and playing the game), whether all the learning outcomes stated in the learning scenario were realized and the possible changes in the scenario before the next implementation.
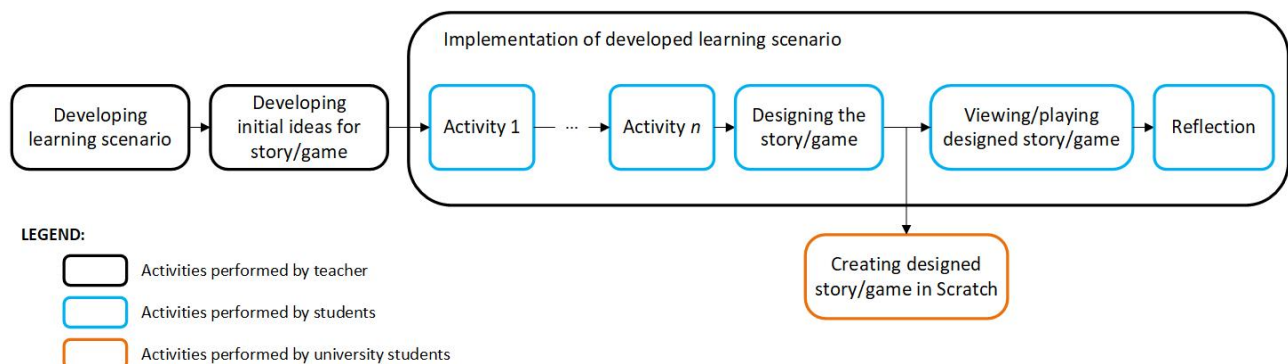
Image 2: Development and implementation of learning scenarios that include digital storytelling

Table 1: Outstanding digital stories with game elements created during the GLAT project

Name	Subject and grade	Story	Game elements	Preview
Seasons [16]	Science 1st grade	A girl named Mia moved from Africa to Croatia and wants to learn about the seasons.	Choose appropriate clothes, seasonal food, and write the names of the seasons.	
Let's eat healthy! [17]	Science 2nd grade	A girl named Tašana goes to the market to buy healthy food for a meal.	Collect healthy food, write the names of the main meals, and put the cutlery next to the plate.	
Cultural heritage [18]	Science 4th grade	A boy named Joseph was abducted by aliens who want to learn about the Croatian cultural heritage.	Mark the Croatian counties where UNESCO sights are located, collect pictures of the intangible cultural heritage.	
Calculation castle [19]	Mathematics 1st grade	To win the princess' hand, young prince must find the golden key and free the princess from the castle.	Collect a number of items (according to given numerical expression), solve word problems.	
Hlapić plays with words [20]	Croatian language	To find his lost friends in a castle, a boy named Hlapić needs to recognize different word classes (nouns, verbs, adjectives).	Sort words, to find a certain word class in a sentence, collect words of a given class.	

Teachers expressed great satisfaction with the prepared scenarios and implementation in the classroom as well as with high motivation of students for creating and playing their own game:

"The introduction of digital games into teaching greatly enhanced my teaching experience and contributed to the fun of the lesson and the project day."

"Learning outcome: Searching, finding, and separating relevant information from the irrelevant has been the most difficult, because this is the first grade. However, I believe that this way of working contributes to developing the ability to search, retrieve and extract relevant from irrelevant information, and that each time further, we will be better at achieving this outcome."

"The developed computer game will serve many other generations, and the motivation for further creation in students and teachers is very high."

"The working atmosphere was wonderful. Students were active and eagerly participated in all the steps of creating the game. When they first played the game, they kept repeating that this is exactly how they envisioned their game."

"Most of my students are involved in the program of early learning informatics, so they were very interested in how the game was developed and expressed their desire to learn how to do it, too."

"Designing this learning scenario was the most challenging for me, but the joy and enjoyment that the students showed while working was worth the effort."

Most of the teachers also pointed out that their students played the game multiple times at school and that link to the game was sent to their parents so they can play at home, too. After playing the game, the students were also interviewed about their experiences.

The favourite part for students during the implementation of learning scenarios was the part when they had chance to play the game they had designed together (Image 3).

The students perceived the game as a fun experience through which they could learn. Many of them indicated that their game is better than the existing examples of Scratch games, precisely because they participated in designing it. It is clear from the following students' responses that the experience of designing and playing the game is positive and that students have accepted this approach to teaching and learning very well:

> *"I liked when we were choosing the characters. We had to draw characters on board. We easily agreed, we voted for ideas. In the game, I liked the maze the most. I learned about the crew of the ship. There was no difficulty, I found it interesting, I felt good. Our game is better because we did it. I would change that game have more levels and tasks because it was too short for me."*

> *"I felt good, a little angry at the first task because I couldn't get through it. There was no difficulty while playing the game. Our game is better because it's more fun and has a lot more colors. I would change the maze to be more difficult and add three more levels."*

4. CONCLUSIONS AND FUTURE PLANS

Using digital storytelling, teachers can encourage their students to become creative narrators, but at the same time enable them to acquire many skills, including computational thinking. Digital storytelling activities can be planned for various school subjects. Students eagerly participate in these activities and they enable them to achieve learning outcomes in a fun way.

This paper presents a model for educating primary junior grade school teachers developed during the GLAT project. Digital storytelling with Scratch is used for achieving learning outcomes of different school subjects as well as for the development of computational thinking skills of students. Teachers' and students' engaged in designing interactive Scratch stories expressed positive experiences.

The GLAT project will end in October 2019. However, activities for promoting development of computational thinking skills will continue at University of Rijeka within the project "Digital educational games". During the project "Digital educational games", possibilities of using GBL in the context of learning, teaching, and promoting inclusive education will be further explored. Efforts on building pedagogical-technological frameworks based on GBL to educate the teachers will be made.

Image 3: Students playing the game they designed

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