

Integrating the 4cs into Creating Games by Visual Programming and Project Based Learning

Vasiliki Choleva¹, Stelios Stagakis², Eutuxia Choleva³ and Charalampos Patrikakis⁴

¹School of Education, National and Kapodistrian University of Athens, Athens, Greece

²Faculty of Science, Engineering and Computing, Kingston University, London, England

³School of Mathematics, University of the Aegean, Samos, Greece

⁴Department of Electrical and Electronic Engineering, University of West Attica, Athens, Greece

vikyhol@hotmail.com

stagakis.st@gmail.com

eutuhol@hotmail.com

bpatr@uniwa.gr

Abstract: In recent years teaching methods and tools have changed due to the development of IT information technologies. The Teaching Learning Process is guided and supported by the use of technological and pedagogical drivers in a holistic way. This paper presents a teaching framework for the development of technologically supported learning environments, through the utilization of visual programming tools, such as Kodu and Scratch, proposed by the current and supplementary National Curriculum. Also, it proposes a framework of educational scenarios as a part of Games Based Learning practices within a Project Based Learning project that will be implemented during languages courses to K-6 students. Seventy-five Greek-speaking children of the fifth year of various primary schools of Athens participated in this study. The aim of the study was not only to examine how the creation of educational digital games with Kodu and Scratch can introduce primary school students to programming but also to investigate the developmental path of 21st century skills such as critical thinking, creativity, collaboration, communication (4Cs) and virtual/digital skills. A mixed method approach was adopted to explore the educational value of using these programming tools in the teaching-learning process. The research data was collected using observations, worksheets and questionnaires. The result of this study shows that the students were excited about the creation of their game by visual programming environments and project implementation, which was reflected by their active involvement in the learning process. The positive results of the research suggest that, in the proposed framework, the visual programming environments Kodu and Scratch can be dynamic learning tools during the teaching of language courses that support the development of students' expression and collaboration skills. Also, the above findings provide an approach for future teaching to K-6 students on developing narrative skills.

Keywords: ICT literacy, 21st century skills, Visual programming, Games Based Learning, Project Based Learning

1. Introduction

Apart from the vast social and technological changes that have been brought about by rapid technological advancements, it also affected education and training. Multicultural classrooms should be moving along with society, cultural trends, and scientific advancements. 21st century classrooms should no longer aim solely towards students' class performance but focus on utilizing school knowledge for the students to develop 21st-century learning skills like (4Cs) Communication, Creativity, Critical Thinking, Cooperation, and also digital literacy competencies like computational thinking (Wing, 2006; Hsu et al., 2018).

In Greece, Curriculum Guides in all subjects are becoming student-centered aiming to assist students to develop their learning skills on their own, as well as their research skills and their creative skills. In the essence of evolving, Programming and ICT courses are getting incorporated into elementary classes with the scope of promoting online learning but also to help students get used to participating in the knowledge-based society by growing their personal skills.

Research projects conducted by the educational society (Resnick et al.2009; Wilson et al., 2013; Chiu, 2020) globally have highlighted the significance of creating toolsets implementation, monitoring, and reviewing the use of visual programming environments for educational purposes. Current, Supplementary and New National Curriculum in ICT strongly recommend the integration of learning activities with the use of visual programming environments for fun activities and for creative expression at all primary school grades, in order to help students, develop problem-solving and computational thinking and to develop as creative thinkers (Resnick, 2007).

Kodu & Scratch, the visual programming environments which were used within our research, also being recommended by the Greek Curriculum (Curriculum in ICT, 2021) because they are powerful dynamic programming tools that can be used by teachers to introduce the students to programming courses in a fun way. They are easy to use and to understand (Chiu, 2020), they can be used to teach basic concepts of computer science (Resnick et al., 2009) and they provide an easy touch interface so that students build their own game only by manipulating graphical elements (Fowler et al., 2012). Moreover, they are also social as they can be linked to a community, where students can support one another and collaborate with one another (Resnick et al., 2009; Maloney et al., 2010).

The paper proposes a teaching framework of educational scenarios with the technical support of Kodu and Scratch and research highlights the way that these digital tools can create a dynamic learning environment during the teaching of language courses, while fostering knowledge and developing collaboration skills, communication, problem solving, decision making and critical thinking skills.

2. The teaching framework

2.1 Case studies-Plan and Objectives

The educational interventions were based on the following axes:

Developing Knowledge transfer skills by exploratory learning and discovery in authentic learning situations

Developing narrative skills, collaborative problem-solving skills and social skills

Relating the educational scenarios to different learning objects (language, sciences, history)

Using visual programming environments as cognitive tools to provide pedagogical guidelines (using a games-based construction approach)

2.2 Research participants-Lesson Overview

The educational interventions were held in different primary school of Athens during language courses to students of the 5th and 6th grade at years 2016, 2017 and 2018 as shown in the table below.

Table 1: Educational interventions

Year	Participants
2016	25 students (13 boys, 12 girls)
2017	25 students (12 boys, 13 girls)
2018	25 students (11 boys, 14 girls)

The students worked in groups of three and four members and they worked in the same pairs throughout the project. 25 of them were introduced to Kodu programming environment and the remaining 50 were introduced to Scratch programming environment. Most of the students had experience using online games. They were given a description of the project and its objectives and all of them were excited as the final product of the project would be their own digital game. Each educational intervention was a course of 12 weeks, as part of their language lessons.

2.3 Pedagogical Approach-Educational scenarios

The educational scenarios based on modern concepts of knowledge and learning and three main components were included as shown in Table 2.

Table 2: To design an educational scenario-three main components

Introductory Framework	Each scenario targets the teaching of the learning object.
Methodological framework	Each scenario targets the teaching of different learning objects, in an interdisciplinary perspective. Each scenario includes instructions for teachers, the theoretical framework and the activity sheets for students.
Principles of design and quality evaluation	Theoretical framework, the teaching subjects, teaching methods, teaching strategies, use of ICT as cognitive tools.

2.3.1 Theoretical framework

The theoretical framework of the scenarios focuses on contemporary teaching methods with modern pedagogical and teaching theories and on the use of technology in the constructivist approach (Papert, 1980; Bruner, 1986; Jonassen, 1994; Prensky, 2001; Van den Belt, 2003; Kafai, 2006).

2.3.2 *The teaching subjects*

The educational scenarios are implemented during language courses to students of the 5th and 6th grade. They target the teaching of the Greek language, investigate the developmental path of narrative skills and are also related to other learning objects (sciences, history) and to specific curriculum areas, in which the visual programming environments can be implemented as a cognitive tool (Komis et al., 2013).

2.3.3 *Teaching methods*

As contemporary pedagogical approaches and modern learning models require the active participation of the learners, the educational scenarios are based on the Cooperative learning (Meng, 2010; Konstantinidis et al., 2010; Fischer et al., 2013) and Project Based learning (Kolodziejcki et.al., 2017; Chiu, 2020) as teaching methods. So, the teacher guides learning by implementing group activities and facilitating interactive experiences in the teaching and learning process.

2.3.4 *Teaching strategies*

The instructional design of the scenarios focuses on the development of the Jonassen Learning Model into the teaching process. The Jonassen Learning Model (Jonassen, 1994) is an instructional design model that is based on supporting the construction of knowledge and collaboration among students and with the teacher. Table 3 shows a breakdown of the lesson plan during the educational interventions.

2.3.5 *Use of ICT as cognitive tools*

The teaching and learning process requires active student participation and communication between students as they design the game world (objects and characters) and they program characters in order to create their own game. The programming environments Kodu and Scratch are used as cognitive tools.

The scenarios are implemented as a set of classroom activities. Table 3 shows a breakdown of the lesson plan during the educational interventions.

Table 3: Teaching and Learning Framework

Time	Teaching Subject	Teaching and Learning Activities
Weeks 1-3	Basic theme of the project Introduction to Kodu or Scratch as visual programming tools, Exploration and Practice	Teacher organizes the project groups and indicates the thematic range by brainstorming Students are given a demonstration of Kodu or Scratch environment characteristics. Worksheets are given to students for classroom work in the computer lab and instructions on how to write basic programs and how to create a basic game with one sprite and one background. Students work in pairs by using Kodu or Scratch command manipulatives.
Weeks 4-6	Narrative stories Scenario game for narrative production	Worksheets are given to students for classroom work in their class to write their picture stories. The stories are designed, illustrated and written by them, only by using Kodu characters or Scratch sprites (Figure1 & Figure 2). Students try to design their scenario game using a combination of storyboard with text.
Weeks 7-9	Building a simple game with a timer Game design using storyboards	Students are shown how to add a timer to their game. Students design a graphical storyboard that represents the sequence of scenes in their final scenario game.
Weeks 10-12	Creating the final game in Kodu or Scratch	Students are asked to complete the final programming project and to finish their digital game.



Figure 1: Worksheets – Scratch: narrative stories “The strange visitor”



Figure 2: Worksheets – Scratch: narrative stories “Lyrics and notes”

2.4 The description of the games

2.4.1 Zante

The game’s environment is based on the island of Zakynthos, Laganas Beach, where a Caretta turtle is struggling to locate a safe place for laying its eggs due to the summer vacation. A lot of tourists with vehicles, boats and tents are storming the beach trying to enjoy their vacation. All these crowds make it impossible for the turtle to overcome the obstacles, so it turns for help to the beach guard Kodu. Time is ticking away while the player is trying to guide Kodu towards the turtle without bumping into obstacles. For every obstacle Kodu hits, he loses energy that can deplete his life bar and lead to game over. Besides obstacles Kodu can reach red trees to refill his energy bar and gain extra points. Will Kodu manage to reach the turtle on time and win the game?

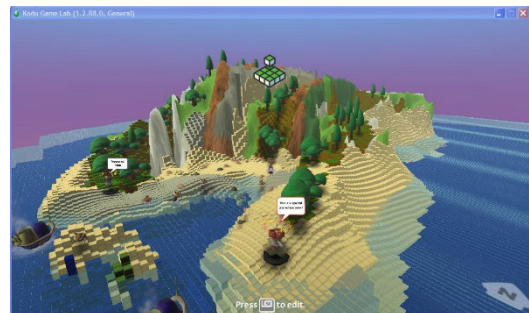
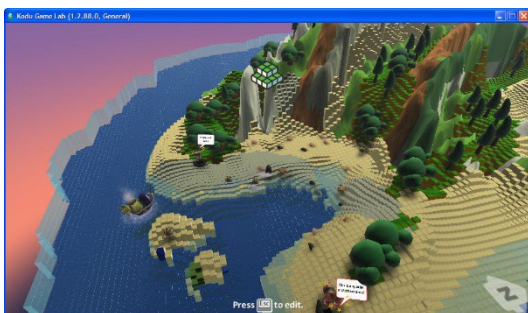


Figure 3: Snapshots: Digital game” Zante”

2.4.2 The treasure of Atlantis

Our hero decides to go on a quest to locate and claim the unspoken treasure lost on the mysterious Atlantis. His only hope is his skills and his fairy friend who accompanies him throughout his quest. Will he prove worthy?

The game promotes problem-solving skills through puzzles while maintaining its adventure core. Basic principles are: 1) The player starts the game with ten (10) arrows and three (3) health bars shaped as hearts for life 2) The player must win battles against critters and creatures to advance to the next level, except for the sea world levels where he needs to avoid everything 3) The player can trade points for more arrows with a cost of 40pts. per arrow.

1st level: The player travels from Europe to Crete in Greece to the Fallen Kingdom of Knossos where he must find his way out of the famous Minotaur Labyrinth. He needs to find his way around the maze where he must face the mythical creature the Minotaur and defeat him. For every hit he takes from the Minotaur, one bar is taken off his health. If he touches the maze walls, he must start over. The reward for reaching the end of the maze and defeating the Minotaur is the first key and 150pts. If he can defeat the Minotaur using no more than five (5) arrows, he wins one hundred (100) bonus points.

2nd level: The player needs to swim across the Mediterranean Sea, while not having contact with any sea creatures. If he gets stung by the octopus, he gets stunned for five (5) seconds where he needs to make ten (10) clicks to break free or else he must start over. If he gets bitten by the crab, controls work backwards. If he gets eaten by the shark, he must start over. For every three (3) times he must start over it costs him a health bar. After reaching the end zone he is rewarded with the second key and fifty (50) points.

3rd level: The player reaches Atlantis where he faces the ocean god, Poseidon who challenges him to battle two (2) gryphons. These mythical creatures spit fireballs, which cost one health bar for every hit to the player. All it takes is five (5) arrows to kill one gryphon. If he succeeds, Poseidon acknowledges his worth and awards him with the third key.

4th level: The player manages to reach the final level, where the treasure chest is lying. He uses the three (3) keys to open the chest and ... win the lost treasure of Atlantis!!!



Figure 4: Snapshots: Digital game “The treasure of Atlantis “

2.4.3 Zeus Mission

Our hero undertakes a journey across the galaxy, aiming to reach planet Zeus with the scope of testing a theory of living conditions on the satellite Europa. He needs to go through the vast surface of Zeus, while overcoming several obstacles, battle alien creatures to reach a mythical diamond that can break through the ice surrounding the satellite Europa.

Will he make it? The game was inspired by renowned scientist Stephen Hawking’s take on alien forms and human colonization on other planets. The game is a combination of action-adventure and puzzles while testing the player’s knowledge.

For the first level, the player starts off outside the Great Red Spot of Planet Zeus. The player needs to enter and pass through the red spot to reach the surface of Planet Zeus. His health bar consists of three thousand (300) ice diamonds, divided into three (3) blocks. Passing through the Great Red Spot can’t be described as an easy task, the player must overcome meteor showers and solve puzzles while the clock is ticking. Meteor hits can deduct fifteen (15%) to twenty (20%) percent of the player’s health according to their size, not solving a puzzle in time will also cost him ten (10%) percent of his health. For every correct answer he is awarded with thirty (30) ice diamonds, while for every wrong one his health bar will be deducted by thirty (30%) percent.

After completing the first level, the player advances to the second level where he starts from the surface of Planet Zeus and tries to reach its core to claim the mythic diamond. The player’s health is determined by his performance on the previous level plus one hundred (100) ice diamonds that are handed to him as a bonus. The player needs to overcome several obstacles, correctly answer questions, solve puzzles, and battle alien monsters to get his hands around that diamond. The level starts off with theoretical questions regarding the Highway Code and then the player needs to go through a practical exam. If the player complies with the Highway Code rules,

he earns twenty (20) ice diamonds. If not, this health bar is deducted by fifty (50%) percent. After leaving the city of Zeus, the player comes across four (4) alien creatures which must defeat. One hit is enough to defeat the aliens except the super alien which will need three hits. For every alien he defeats he is awarded forty (40) ice diamonds and for every blow he takes from the aliens his health bar is deducted by five (5%) percent. The diamond is essential for advancing to the next level and completing the game. The player must have at least five thousand (500) ice diamonds at his disposal to unlock the diamond, if not he needs to start over.

For the third and final level, the player's health is determined by his performance on the previous level. The player needs to solve a last puzzle by answering several questions correctly and then he must break the ice of satellite Europa with the use of the diamond. If he succeeds, he reaches the game's finishing line.

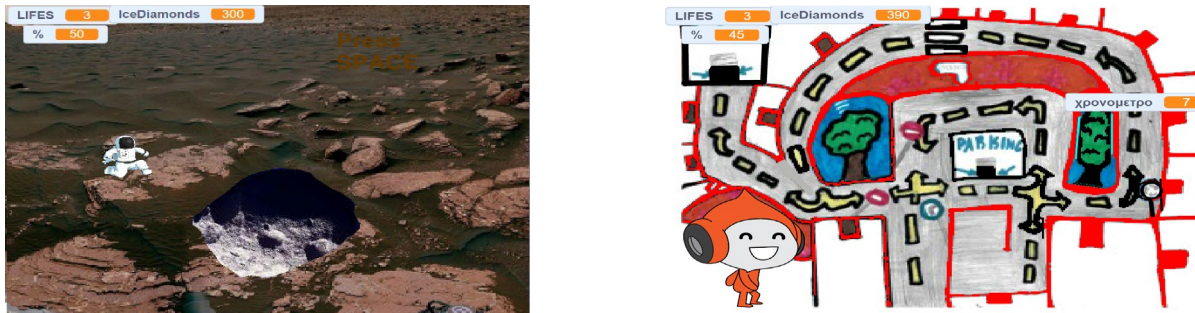


Figure 5: Snapshots: Digital game "Zeus mission"

3. Evaluating the educational interventions

In the context of this research, issues concerning the design and the implementation of technology supported learning environments through the use of visual programming tools such as Kodu and Scratch. Furthermore, it examines the way that the programming environments through game-based construction can be the best used as teaching and cognitive tools as well as their contribution to the development of learning and social skills. Analysis results revealed that collaboration between students worked almost flawlessly and when educational gaming is used in the learning process to teach ideas in engaging and interactive ways it causes positive reactions to students. Also, the description of a scenario game serves as an excellent text for languages courses emphasizing multiple approaches to the study of narrative.

3.1 Observations

The results of the evaluation process derived from direct observation during the educational interventions as the teacher-researcher investigates the contribution of the visual programming tools in the teaching-learning process through authentic teaching examples. The researchers observed especially the following topics: what was difficult, what was too easy or boring for the students while approaching the programming environments during the implementation of their games (formative evaluation).

According to our survey, all participating students found the experience highly satisfying. They were excited by programming with Kodu and Scratch and by working collaboratively, using programming to express their ideas. Most of them engaged with the game at the school lab without going out for a break and they continued their work at home. All of them were motivated by designing their scenario game and they developed meaningful storyboards.

3.2 Questionnaires

The results of the evaluation process derived also from the questionnaires completed by the 75 participants after the implementation of their digital games.

The teacher researcher and the other two researchers developed the questionnaires using questions from a teaching framework in Kodu Curriculum which was designed for a Microsoft DigiGirlz Technology camp (Kodu Game Lab: Kodu Teacher Guide), adapted the questions for K-6 students and added questions based on the goals of the research. The questionnaire of each programming environment consisted of 21 closed questions to be answered on a five – point Likert scale ranging from *strongly disagree* to *strongly agree*. The statements in the questionnaires were divided into three categories: Attitudes towards computers and programming, attitudes

towards the use of visual programming environments and attitudes towards the use of educational games in the learning process. Table 4 presents some items from the three different categories.

Table 4: Questionnaire categories

Attitudes towards computers and programming
I spend more than 2 hours each day playing video games
I know a lot about computer programming and visual programming languages
If my school offered a computer science class next year, I would take it
Attitudes towards the use of visual programming environments
Playing games in Kodu or Scratch is easy
Creating games in Kodu or Scratch is easy
My team worked well as a group during the creation of our game in Kodu or Scratch
Attitudes towards the use of educational games in the learning process
I decided to try out Kodu or Scratch because I wanted to create my own game
I used to study at home by using Kodu or Scratch command manipulatives, in order to finish my game
I recommend the existence of digital games in other lessons too

Almost all of participating students found the visual programming tools useful for them with a simple visual interface that allows them to create their own digital game or their animation (95% positive review). 90% of the students indicated that they enjoyed working together on the design of their games and 85% of them particularly liked the fact that they can share their digital games online and can introduce the game to their friends.

Finally, 84% of the students demonstrated a positive attitude toward the use of the educational games by the visual programming tools in the learning process, as shown in Table 5.

Table 5: Attitudes towards the use of educational games in the learning process

	Frequency	Percent	Valid Percent	Cumulative percent
negative	3	4,0	4,0	4,0
neutral	9	12,0	12,0	16,0
positive	63	84,0	84,0	100,0
Total	75	100,0	100,0	

4. Conclusions

The aim of this paper was to summarize the effectiveness of educational scenarios as a part of Games Based Learning among primary school children. The intersectional educational scenarios were designed and implemented to develop narrative skills during language courses, in the context of project method application in educational practice.

Meanwhile it managed to enhance the participants’ active participation and creative expressions since the scenario’s theme/topic are based on their personal interests and real-life based applications. In addition, they grow the participants’ digital skills, imagination and creative thinking through the process of developing their own digital game. As Resnick (2017) stated: by creating opportunities for children and teens to work on projects, based on their passions, in collaboration with peers, in a playful spirit, we will be able to prepare them for a world where creative thinking is more important than ever before.

Kodu and Scratch Visual Basic Programming Environments were used for the teaching activities of the educational scenarios along with the development of project method. The outcome of the presented research contributes to the existing findings of similar research that aim to successfully integrate this methodology of developing digital applications or games with the use of Visual Basic Programming Environments during the introductory Programming courses and for developing social and other skills like thinking creatively and working collaboratively (Resnick et al., 2009).

Research findings have proven that the utilization of these programming environments for educational purposes has positive effects on the development of several skills like cooperation, communication, problem solving along with social interacting. The features of the Programming Environments seem to bring out an amusing effect for the participants, while the ability to create their own game was really intriguing for them.

The students were given the chance to realize their ideas-scenarios into digital worlds, heroes, and objects during the game-based learning activities. The outcome was quite impressive, they managed to develop games with an exceptional plot, clear instructions, and goals. Also, the researchers observed that by not having syntax complexity, Scratch and Kodu allowed beginner programmers to solve complex problems quickly.

During the development process, all the participants were constantly interacting and cooperating in groups to produce the best results. After completion they seemed eager to share their game not only with one another, but also on the program development forums.

To conclude, regardless of the learning activities or the teacher's capabilities, for the development of learning skills but also for achieving higher learning goals, teachers should embrace pedagogy theory and the value of utilizing Logo, the first child friendly programming language, if used properly.

They should really try to promote the creative side of programming, since any programming activity is an essential tool for all learning activities in multicultural classes of the 21st century.

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