Technium Education and Humanities
Technium Education and Humanities
Vol. 10, pp.41-54 (2024)
ISSN: 2821-5079
www.techniumscience.com

Use of learning theories and visual programming (scratch) in education

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Abstract. *The integration of educational software into education has opened new horizons for learning for both students and teachers. In this particular work we deal with Scratch, which provides students with the opportunity to grasp the concept of interaction between objects while implementing small games.*
The purpose of the present work was to develop an educational application (Scratch), which can be used as auxiliary material in the elementary school Mathematics lesson, and in particular in mathematics operations related to addition, subtraction and multiplication.
Learning Theories related to their integration into educational software are also studied, the main Theories of their use in educational programs are presented and their characteristics are identified.Finally, there are suggestions in this application that use behavioral techniques that are mainly located in the actions of applause or disapproval after each students response.

Keywords: SCRATCH, Learning Theories, Educational Software, Visual Programming, Mathematics

Introduction

In the 21st century, the term "technology" is an important issue in many fields, including education. This is because technology has now become a channel for knowledge transfer in most countries. Technology today has become innovative by completely changing the way people think, work and live. [1].In this context, schools and other educational institutions that prepare their students to live in a "knowledge society" should consider integrating ICT into their curriculum [2].

ICT integration in education refers to the use of computer communication integrated into the daily teaching process in the classroom. In conjunction with preparing students for the current digital age, teachers are considered key players in the use of ICT in their classrooms. This is due to the ability of ICTs to provide a dynamic and proactive teaching-learning environment [3]. While the goal of ICT integration is to improve, increase the quality, accessibility and cost-effectiveness of instruction to students, it also refers to the benefits of networking learning communities to address the challenges of today's globalization. The process of ICT adoption is not even a single step, but rather continuous and ongoing steps that fully support teaching and learning and information resources [4].

The integration of ICT in education is the process of technological teaching and learning that is closely linked to the use of technologies in schools. Due to the fact that students are now familiar with technology, the issue of ICT integration in schools, especially in the classroom, is crucial. This is because the use of technology in education contributes significantly to the pedagogical aspects in which the application of ICT leads to effective learning [5].

1. 1. Theories of behaviour and cognitive theories

Behavioural theories derive their philosophy from the positivist scientific paradigm, whose main question is "how it is possible to acquire indisputable knowledge, about reality, sensory experience, (positive) facts, which constitute the indisputable and valid domain of the search for knowledge".

They take into account exclusively the changes and transformations of externally observed behaviour. Because the internal mental processes of the subject do not lend themselves to observation, they cannot be studied directly according to the researchers. For this reason, Behavior Theory researchers systematically study only the external response of the subject and reject hypotheses or interpretations based on the internal mental processes of the subjects. For Behavioral Theories, it could be said that students' brains are a "black box" and the cognitive processes that occur in it are not the subject of research [6] .

In Behavioural Theories what is of interest is only the external stimulus from the environment to individuals and the response of individuals to the given stimulus. Learning is the connection of response stimuli and because repetition strengthens connections by extension it also strengthens learning. Learning is therefore a matter of making connections between stimuli and responses). At the same time, positive reinforcements, such as rewards, for example, strengthen a particular 'learning', while negative reinforcements weaken it [7].

Ivan Pavlov

Ivan Pavlov presented one of the main trends of the Theories of Behaviour, the classical substitution-interconnection theory, this theory was later promoted by John B Watson

Pavlov's theory of learning was based on experiments he conducted with a dog. During the experiments Pavlov found that the dog exhibited saliva secretion not only at the sight of food, a natural automatic response of the animal, but also at the footsteps of the guardian carrying the food, an essentially neutral and irrelevant stimulus [8].

These observations led Pavlov (conditional learning) to the conclusion that learning occurs when we manage to co-ordinate a neutral stimulus with a response, which may also be initially triggered by a natural stimulus. In contrast, the neutral stimulus does not initially bring about this reaction [8]. Then by co-dependence, i.e. the topotemporal relevance of the neutral and physical stimulus as well as the reaction, the occurrence of the physical reaction with stimulation caused by the neutral stimulus initially is achieved.

John B. Watson

According to John B. Watson, Classical Dependent Learning comes to "explain" simple forms of learning, giving more importance to learning or changing emotional and parodic forms of behaviour. Today this model has been explored by including in the term "stimulus" also cognitive stimuli such as symbolic - mnemonic representations and in the term "response" also inner experiences that influence the emotional world [9].

Edward L. Thorndike

Edward L. Thorndike introduced the trend of factor substitution which was subsequently promoted by B.F. Skinner who refined, popularized and extended it. According to this trend we have use of rewards and penalties aimed at changing behavior - learning, we have by reinforcing (positive or negative) a relationship that already exists between stimulus and response [10]. He argues that the basic stimulus which reinforces learning is not created from scratch, but follows a specific desired response, which is why his method is called active contributory learning. According to it, behaviour that is immediately followed (i.e. combined) by positive reinforcement (reward) is repeated and learned, whereas behaviour followed by negative reinforcement (punishment) disappears [11].

B.F. Skinner - Principles of Behavioural Learning - Planned Teaching

According to Skinner's Planned Instruction (Skinner) the student's participation is active. The material is structured in short teaching units and presented according to his/her learning rhythms. In Planned Instruction, the student's efforts are reinforced, his/her answers are directly verified during assessment and he/she is rewarded for correct answers[12].

Skinner - Application of Behaviorism - Linear Organization

Learning proceeds linearly without branching (Skinner machines). The sequence of material is designed in such a way that all students can follow it. Each teaching step consists of four elements:

1. a piece of information,
2. a question,

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Vol. 10, pp.41-54 (2024)
ISSN: 2821-5079
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3. a blank for the student to answer, and
4. the correct answer.

2. Cognitive theories

Cognitive Learning Theories emerged as a result of reflection and criticism of Behavioural Theories, since these theories misunderstand what happens inside the mind of the learning individual. All efforts are directed at explaining the internal processes of cognitive development and learning [13]. They focus on "how" the learner ultimately learns. Each learning event is a dynamic system, consisting of simpler or related dynamic systems. Cognitive structures and processes are not the same at all ages, but change as the individual develops, both as a result of biological maturation and as a result of the influence of the experiences the individual acquires. Thus, the child is not a miniature adult, nor do its cognitive mechanisms work in a manner analogous to that of an adult [14].

Many of the findings of Cognitive Theories are distanced from the research approach of Behavioral Theories to explain human learning, which does not take into account the cognitive functions of the individual [15]. The studies of research psychologists no longer focus on the role played by the associative coherences of the environment in the manifest behaviour of the individual, but emphasize the cognitive structures and the internal mental processes of the individual, according to which he perceives, understands the relationships of things and events, builds new knowledge, thinks and reacts to various situations [16].

Cognitive [17] are as follows:

- The schema theory

Schema theory (schema theory). The schema theory (schema theory) refers to the reference to schema; it is an organized structure that exists in memory. All schemas together form a schema is a reference to a structure that is stored in an organized structure.

Our knowledge of the world we live in. It is made up of concepts of what we know. structured in networks with interconnected nodes connected by links. Learning occurs as the schemas change, adapting to new information in the environment, which is assimilated into them by accretion, micrometric corrections and the creation of new schemas.

- Encoding and information mapping

Refers to the way information is recorded and organised in memory by means of schemas. Also, the interconnection of these with new incoming information.

- Mental models

Internal mental construct similar to a schema, but broader in conception.

- Development of expertise

Knowledge represented by schemas or mental models changes as the person works, over time. It becomes more accessible and usable effectively, without conscious effort. At the same time, its structure becomes more stable. Thus, its recall becomes simpler, almost automatically, without our conscious attention[18].

- Information processing - Symbol manipulation - Knowledge construction They refer to the way cognitive processes act on mental representations, which change over time. Changes in mental representations mean changes in a person's knowledge of his environment, which is called learning. Cognitive processes are divided into three categories: information processing, symbol manipulation and knowledge construction.

The main features of these theories are:

- the cognitive system is organized and evolves towards states of mind equilibrium
- knowledge is not a copy of reality but an assimilation of reality
- I know an object when I act on it and transform it
- cognitive processes are a continuous processing function
- every cognitive process consists of representations and of processing
- knowledge is structures fixed in "long-term memory"

- representations are differentiated from knowledge because they are automatically active whereas knowledge must be activated in order to be available
- knowledge is linked to action in order to model and transform reality

Cognitive Theories, like Behavioural Theories, are based on the view of objective knowledge. The goal has remained the same, namely to transfer knowledge in the most effective way. Cognitive Theories imposed metaphors in education, the analysis of complex into simple concepts and the careful organization of educational materials from simple to complex.

The greatest of the researchers whose work is associated with Cognitive Learning Theories are C. M. Reigeluth, M. D. Merill, R. C. Shank, R. Gagne, L. Briggs, W. Wagner and R. E. Mayer [19].

The software inspired by Cognitive Theories are software, which try to exploit the basic stages of knowledge acquisition i.e. information reception - retrieval or recall - processing - storage. An attempt is made to simplify cognitive schemes by breaking down complex concepts into simpler ones, allowing for comparison, while feedback is provided to encourage and develop self- confidence [20]. The learner is encouraged to get in touch with the software, to experiment and create his/her own way of acquiring knowledge.

3. Case study

In this section, we present the creation of an interactive game implemented in scratch. The application was created entirely through the web platform and concerns the assessment of knowledge in arithmetic operations: +, -, *.

The aim of the game is to test students' knowledge in the form of a self-assessment exercise, which has levels of graded difficulty. The student can choose to exit the game at any time, and to advance to the next level, the student must complete the required number of correct answers.

The structure of the game includes exercises-questions structured in 3 levels of difficulty, according to the structure below:

- Level 1: this level includes n mathematical expressions of addition, to which the user is asked to answer if he/she agrees with the result of the operation.
- Level 2: this level includes n mathematical expressions of subtraction, where the user is asked to state the correct result.
- Level 3: this level includes n random mathematical expressions (addition, subtraction or multiplication), where the user is asked to state the correct result.

The general rules of the game are displayed to the student at the start. To be able to play the questions of a level, the user must have completed the required number of correct answers of the previous level, in particular having higher than 50% correct answers. Also, at the beginning of each level the specific rules-instructions applicable to that level are given.

The game is designed in such a way that all questions are generated automatically, i.e. my mathematical expressions are formulated using variables which accept random numbers at predetermined intervals. Also through the use of iterative structures the user can easily and quickly vary the number of answers.

At this point the data used to synthesize the application is presented:

Backdrops: a total of 3 backgrounds were used.

- The backgrounds "main_bg1" is used while the student is performing the exercises.
- The background "main_bg2" is used at the beginning during the presentation of the instructions and when the student fails to complete a level.
- The background "game_over " is used when the student chooses to exit the game. Sprites: A total of 7 objects were used.
- The "Unicorn" object is used while the student is performing the exercises and performs actions whenever the user successfully completes a level.
- The "Balloon1" object is used every time the student successfully completes a level, as well as when the student successfully completes the game.
- The "Button1" object is used during the execution of level 1 questions.

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Vol. 10, pp.41-54 (2024)
ISSN: 2821-5079
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- The 'Button2' object is used during the execution of level 1 questions.
- The 'Marian' object shall be used at the start of the game when the instructions are presented, and when the student fails to complete a level.
- The "exit" object remains active throughout the execution time of the application and is the button object that when selected exits the game.
- The "Ballerina" object is used when the student succeeds in completing the game.
- Variables: a total of 11 variables were used.
- The variable "counter" represents the number of questions completed (successfully or unsuccessfully) at each level.
- The variable 'i' is used as an auxiliary variable for the needs of the exercises of level 1 and 2.
- The variable 'number1' is used in all three levels and represents a random integer number within a certain range of values (which varies according to the level).
- The variable 'number2' is used at all three levels and represents a random integer within a certain range of values (which varies according to the level).
- The variable 'random_error' is used as an auxiliary variable in level 1 and expresses a random integer number in the interval [-1,1]. It is essentially the variable which affects the correctness of the mathematical expression in the exercises at level 1.
- The variable "score" expresses the number of questions that have been successfully completed in total.
- The variable 'score1' expresses the number of questions successfully completed at level 1.
- The variable 'score2' expresses the number of questions successfully completed at level 2.
- The variable 'score3' expresses the number of questions successfully completed at level 3.
- The variable 'state' expresses the level that is active. Through a control structure, depending on the value of the variable, the corresponding level of questions is activated.
- The variable "var_run" expresses the value of the position of the object "Unicorn" with respect to the x-axis. It is used to move the objects " Unicorn " and "Balloon 1" with the completion of each level.

Application presentation

For the purposes of demonstrating the application, a small number of n questions per level was chosen, namely five questions per level. To complete each level, the number of correct answers per level is required to be ≥ 3.

Launch

At the start of the game (by selecting the feature icon) a number of variables are assigned initial values. The reason for this is that this is how we reset the values of variables that may have a different value from a previous iteration of the game.

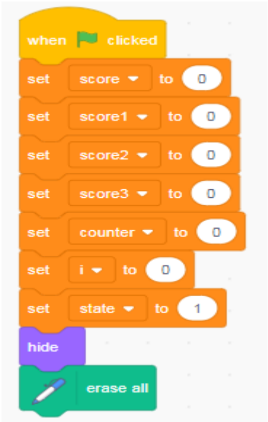

Figure 1: Start game - Unicorn object

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Also when the application is started, the value of the "state" variable is declared in unity in order to activate the 1st level (details of the control structure regarding the active level will be given later).
Along with the above actions, a set of actions related to the "Marian" object is also performed, as shown in the following figure.

Figure 2: Start game - Marian object

At startup, the transfer is made to the background "main_bg2" where the "Marian" object appears to give the general instructions of the game. All phrases are displayed for the time specified, with the exception of the last one which prompts the user to press any key.
Finally, at the start actions have been set on other objects as well. These actions primarily concern the appearance or non-appearance of objects.
Level control
As soon as the student presses a key (either at the start of the game or on completion of a level), a check is made on the level at which the game should continue. The structure of the control is shown in the figure.

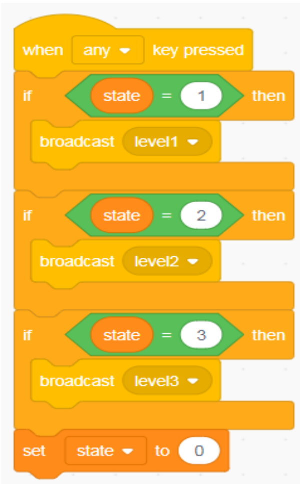

Figure 3: Active level control

So when the student presses a button, it checks which stage of the game the student is in. This is achieved by using the "state" variable. The values 1, 2 and 3 express levels 1, 2 and 3 respectively. Depending on the value of the variable 'state' at the given time, the corresponding level is activated by means of the broadcast command.

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The commands that are executed depending on the level at which the learner is located are then displayed.

Level 1

Once it has been verified by the control structure discussed earlier that the level that is active is level 1, the following structure is activated.

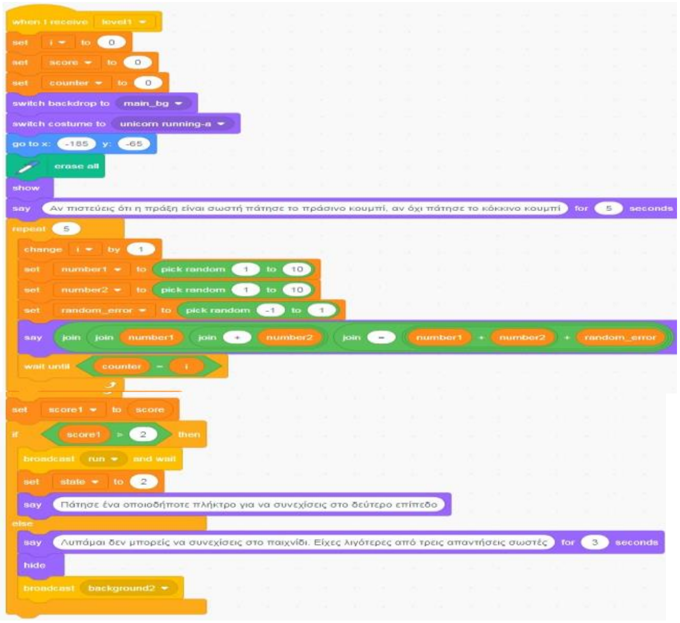


Figure 4: 1st Level

Once the 1st level is activated, we first define the values of the variables we want to use as well as the background and costume we want to be active for the object.

In the 1st level the student has to evaluate 5 mathematical addition operations and answer whether the operations depict the correct or not result. The answers are given by pressing the appropriate button on the game desktop (the right and wrong buttons are expressed by objects and are discussed below).

An iterative structure is then displayed where, depending on the number of questions we want to display at this level, the number of iterations in the structure is defined (in this demonstration the number of iterations is 5). The variables "number1" and "number2", accept a random integer value between 1 and 10 in each iteration, while the variable "random_error" accepts a random value from {-1,0,1}. This last variable is used to generate a random error in the mathematical expressions. When the value of "random_error" is 0 then the mathematical expression presented is correct, while in any other case it is wrong.

At level 1, the student indicates whether he/she believes that the result of addition is correct. The student's answer is entered by pressing the corresponding button (green button for yes, red button for no). The green button is the object "Button1", while the red button is "Button2".

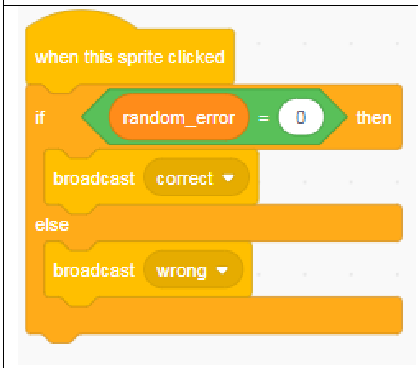
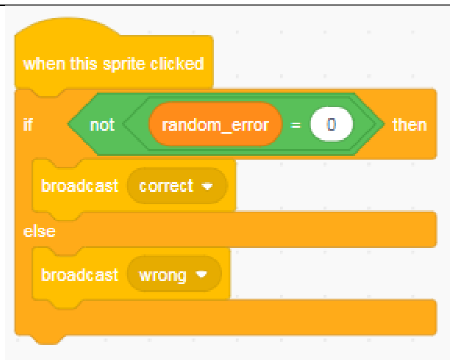
Button1	Button2	Objects
		

Figure 5: Button 1 & 2, objects

As can be seen, each time one of the two buttons is selected, a check is triggered to determine if that particular selection is the correct one. This is accomplished by using the "random_error" variable. When the answer is correct, then the message "correct" is transmitted, otherwise the message "wrong" is transmitted.

According to the image above, every time "correct" is received, the characteristic phrase "Bravo!!!" is displayed accompanied by a characteristic reward sound and the value of the score variable is increased by one unit (the score stores the number of correct answers in the game), as well as the value of the counter variable (the counter stores the number of answers given per level). Note that these messages are used by all levels of the game.

After the number of questions is completed, a check is made on the number of correct answers in order to decide whether the game should continue to the next level or not. Given the fact that 5 questions per level are considered, the minimum number of correct answers per level is at least 3 (which is indicated by checking the condition score1>2).

* The actions taken after checking the score of each level are essentially common to each level and are discussed below.

Level 2

As long as the student completes at least 3 correct answers in level 1, he/she can continue to the next level. In level 2 there are 5 questions in which the student is asked to type the correct result of the subtraction.

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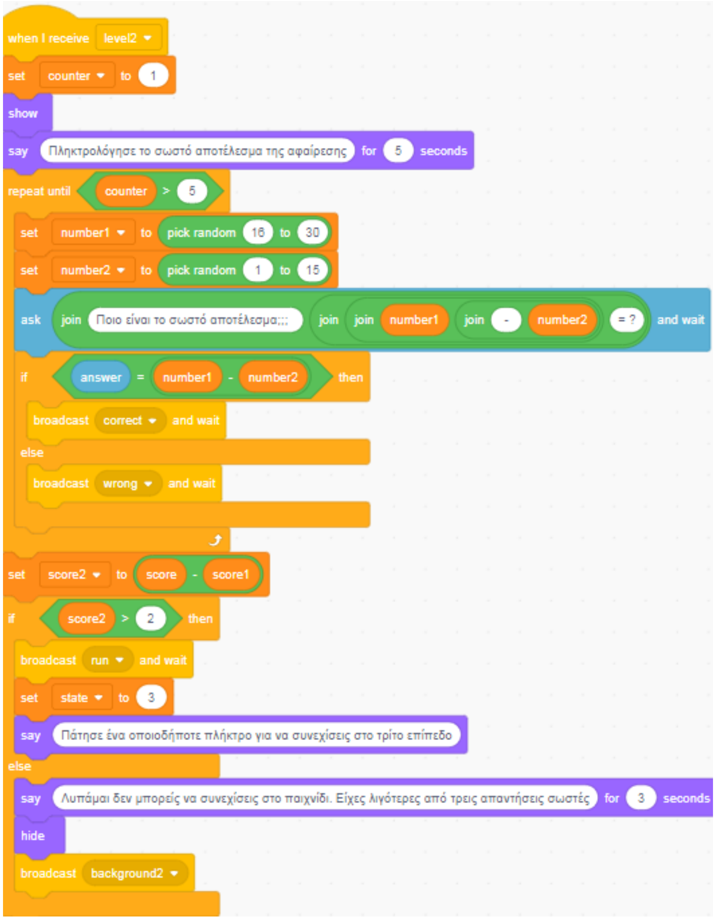

Figure 7: Level 2

As shown in the figure, also in this case the numbers that appear in the subtraction operation are defined by means of the random function and of course the result is checked automatically.

Once the student's answers are completed, a check is performed to determine whether or not the student will continue to the next level.

Level 3

In level 3 which is the last level in the game, the student has to answer 5 questions where both numbers and operations are defined in a random way.

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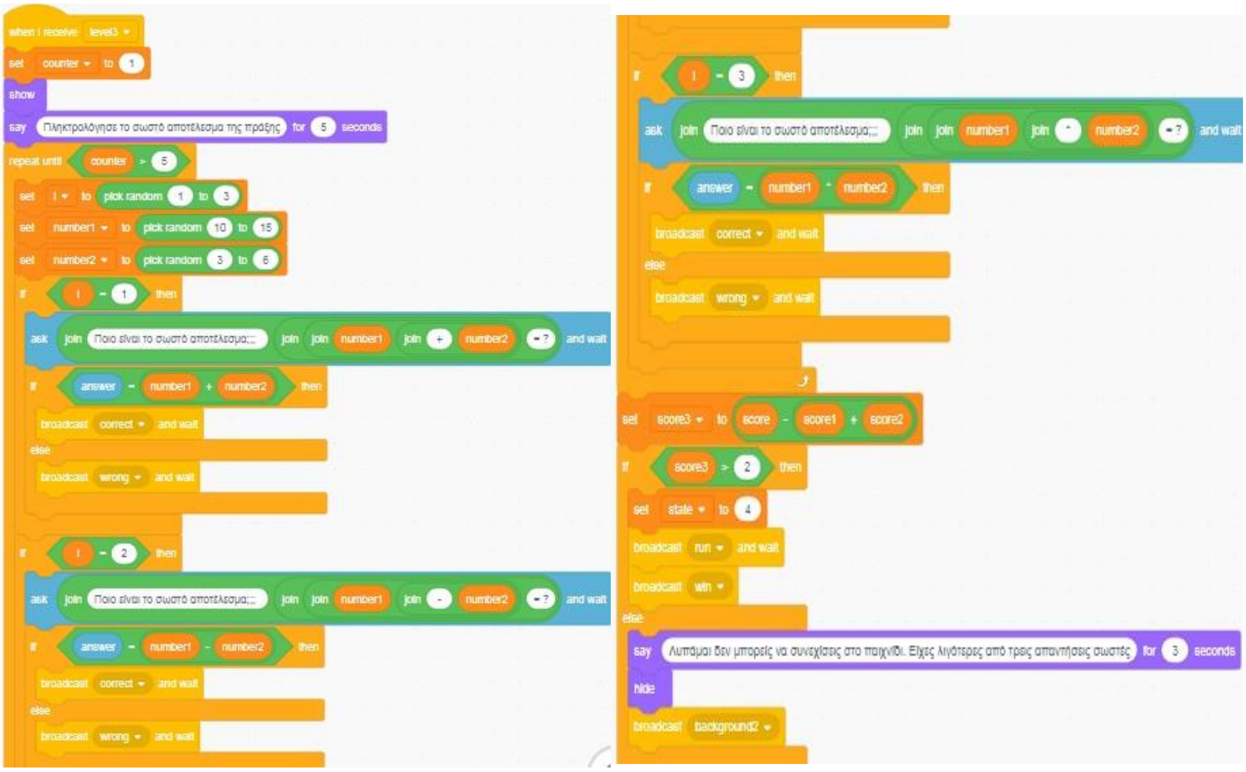

Figure 8: Level 3

According to the figure where the structure of the 3rd level is shown, besides the two variables that accept a random integer value in a certain range of values, there is also the variable i, which in this level accepts the values {1,2,3}. Each value corresponds to an arithmetic operation, namely {add=1, subtract=2, multiply=3}.

Depending on the value of variable i, the student is asked to calculate the correct result of the corresponding operation.

Actions performed after successful completion of a level

When the student successfully completes a level, the message "run" is transmitted which refers to actions performed by the "Unicorn" object and the "Balloon1" object.

The actions performed by the two objects are summarised in the following figure.

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<table>
<tr><th>Unicorn</th><th>Balloon1</th></tr>
<tr><td>


</td><td>


</td></tr>
</table>

Figure 9: Actions of Unicorn & Balloon1 objects since the transmission of the run message

As mentioned after successful completion of some level, the run message is transmitted. In this case the two objects, perform actions primarily related to sound and position actions.
Through the use of the variable "var_run" (which has as its value the position of the Unicorn object with respect to the x-axis) and the various costumes of the Unicorn object, the visual effect of "running" is achieved. Also, upon completion of the movement of the Unicorn object, a balloon (object Balloon1) is released which is directed towards the "exit" object.
Actions performed after unsuccessful completion of a level
When the student unsuccessfully completes a level, the message "background2" is transmitted, which mainly concerns actions performed by the "Marian" object.
The iteration structure shown in the image above allows the object to move through the change of clothing. At the end of the actions, the student is asked to choose whether to start the game from the beginning (by pressing any button) or to choose exit from the game by selecting the Exit button (corresponding to the exit object).
Exit object
The exit object remains active throughout the game and is the only way for the user to choose to exit the game.

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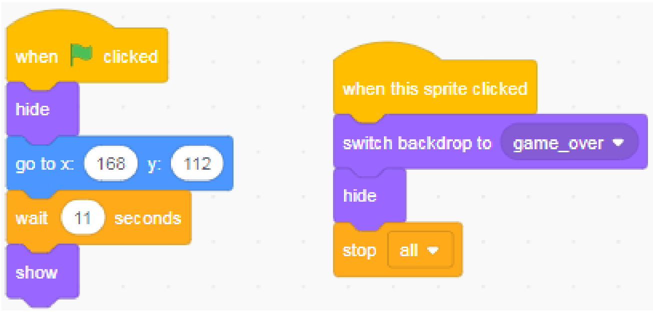

Figure 11: Exit object actions

So when the student selects the specified object, the background changes to the "game_over" attribute and all actions in progress are terminated.

Successful game completion

As soon as the student successfully completes the 3rd level, the win message is transmitted.

This message affects the objects "Ballerina" and "Balloon1". The set of actions for these two objects is shown in the images below.

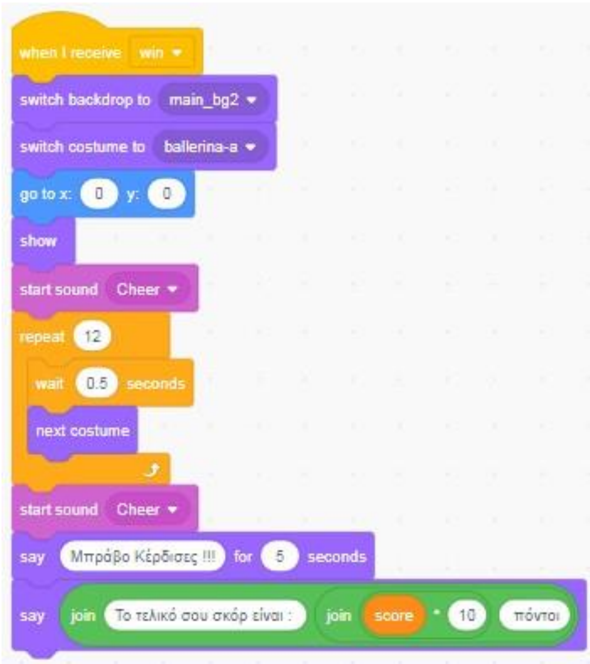

Figure 12: Ballerina object actions

Upon successful completion of all three levels of the game, the "Ballerina" object performs a set of appearance and movement which are accompanied by corresponding reward sounds.

At the end the object displays the student's final score which is calculated by the number of correct answers multiplied by the number 10. The maximum score a player can receive is 150.

Conclusions

The purpose of this study was to demonstrate the effectiveness of visual programming as a tool in the educational process. Through the application implemented in scratch it was found that material can be created which contributes to the teaching practice in a supportive way. One of the most important advantages of its use is the interaction achieved between the application and the student.

Through this particular application, it is evident that structures can be implemented that allow the creator to automate processes and additionally, with small parameterizations, to vary the volume-quantity of the questions being examined. It is also important that the possibility of examining-evaluating a wide range of material is given through the integration of several levels of exercises. In addition, through the proper structuring of the programme it is relatively easy to ensure that the levels of exercises maintain a graduated level of difficulty.

Finally, it should be noted that by using appropriate visual and sound effects, the developer can tailor the application in such a way that it incorporates desired elements from learning theories. Behavioral techniques were used in this application, mainly identified in the actions of approval or disapproval after each student response.

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