Utilizing Sphero for a speed related STEM activity in Kindergarten

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Abstract

STEM education is being gradually adopted by all levels of Education. Kindergarten lately attracts more attention from the STEM education policy makers because it is believed that children who develop an interest in STEM at a young age are more likely to excel in the future and avoid stereotypes or other obstacles when entering STEM fields in later years. In this paper the design of a teaching activity for approaching the notion of speed in Kindergarten, utilizing the Sphero SPRK robot, is described. The proposed activity is part of a postgraduate dissertation, still in progress.

Keywords: STEM, Kindergarten, Speed, Sphero

1. Introduction

STEM was firstly introduced in the 1990’s by the National Science Foundation and has been used since, as a generic label for any action, policy, program or practice that involves one or more of the STEM disciplines: Science, Technology, Engineering, & Mathematics [1]. STEM education can be defined as an integrative approach to curriculum and instruction, content and skills, approaching all the STEM areas as one, without any boundaries between them [12, 11]. Through STEM education, students can develop 21st Century skills like adaptability, problem solving, complex communication and system thinking [17]. Generally, STEM education seems to have some benefits, as students become better problem solvers, innovators, logical thinkers, inventors, and technologically literate [13]. Also, students become STEM literate through this kind of educational approaches. STEM literacy includes the conceptual understanding and procedural skills and abilities for individuals to address not only personal, but also social, and global issues [1]. Recently, a new tendency is evident, suggesting the exploitation of artifacts in STEM education, for fostering creativity and innovation among students through a more attractive way of STEM education. Thus Arts are proposed as an additional constituent, leading to the generation of the STEAM term (Science, Technology, Engineering, Arts & Mathematics) [24].

It seems that STEM programs can be implemented in Kindergarten. Children from a very early age formulate theories and ideas for just about everything, and these ideas play a significant role in the learning experience [9]. Even before they become involved in any educational system, they form ideas for a variety of physics’ phenomena around them, thus constructing definitions about them. Through community, and social interactions children look up for definitions of the world around them [2]. Also, according to the recent and growing recognition of the role of stimulation in early brain development, it seems that preschool training programs and
Kindergarten in particular, provide a significant place to start focusing on STEM education in order to obtain positive fruitful results in the future [26].

The proposed activity is part of a postgraduate dissertation in progress. In this paper the design of STEM related activities about the notion of speed in Kindergarten, is described. More specifically, activities with the robot Sphero SPRK, are suggested in order to introduce the notion of speed in Kindergarten. The present paper is structured as follows: firstly, the theoretical framework is presented. Then, the proposed activities are described, followed by a concluding discussion.

2. Theoretical Framework

Speed is defined as the distance covered per unit of time (speed = distance/time). It was first measured by Galileo, considering the distance covered and the time needed to achieve that. Velocity combines both the ideas of speed and direction of motion. In general, speed is a description of how fast an object moves and velocity is how fast it moves and in which direction [6]. In the New Curriculum for Kindergarten in Greece [19], speed can be found in Physics Science section, specifically in the “Notions and phenomena from the natural world” part, under the topic “Simple physics phenomena about: the motion of objects…”. Also in the Interdisciplinary Frame Curriculum for Kindergarten in Greece [8] speed can be found in section “Child and Mathematics”, specifically in the “children should be able to compare the speed of objects’ motion compared to time when the distance is same” part and in the “Natural Environment and interaction” topic. In the latter case, the pursued ability to be cultivated is “to perceive the motion and its principles”.

Inquiry, as a term, is used throughout the science education literature to describe goals for science learners as well as approaches for science teaching [15]. Students who use inquiry to learn science are engaged in many activities and thinking processes which are similar to those scientists do [14]. Classroom inquiry can occur at all grade levels of education [15]. “Inquiry is a multifaceted activity that involves making observations; posing questions; examining books and other sources of information to see what is already known; planning investigations; reviewing what is already known in light of experimental evidence; using tools to gather, analyze, and interpret data; proposing answers, explanations, and predictions; and communicating the results. Inquiry requires identification of assumptions, use of critical and logical thinking and consideration of alternative explanations [14].

Some practices that can take part in K -12 science classrooms are: a) Asking questions (for science) and defining problems (for engineering), b) developing and using models, c) planning and carrying out investigations, d) analyzing and interpreting data, e) using mathematics and computational thinking, f) constructing explanations (for science) and designing solutions (for engineering), g) engaging in argument from evidence, and h) obtaining, evaluating and communicating information [18].

Scientific investigation, inquiry and engineering design are closely related activities that can sometimes be mutually reinforcing in many curricula. Scientific inquiry and engineering design are often compared to each other, because of the problem-solving approach that they both use. It seems that certain science concepts including the use of scientific inquiry methods can support engineering design activities [16]. The engineering design process offers a context which can support educators when teaching inquiry and scientific reasoning. The engineering design process is compared with the scientific inquiry process, as shown in Table 1 [22]:
Table 1. Comparison of the Engineering Design Process and the Scientific Inquiry/Investigation Process

<table>
<thead>
<tr>
<th>Engineering Design</th>
<th>Scientific Inquiry</th>
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</thead>
<tbody>
<tr>
<td>1. Identify the need or problem</td>
<td>1. Formulate the problem</td>
</tr>
<tr>
<td>2. Research the need of problem</td>
<td>2. Information gathering</td>
</tr>
<tr>
<td>3. Develop possible solutions</td>
<td>3. Make hypotheses</td>
</tr>
<tr>
<td>4. Select the best possible solution</td>
<td>4. Plan the solution</td>
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<tr>
<td>5. Construct a prototype</td>
<td>5. Test solutions (perform experiments)</td>
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<tr>
<td>6. Test and evaluate the solution</td>
<td>6. Interpret data, Draw conclusions</td>
</tr>
<tr>
<td>7. Communicate the solution</td>
<td>7. Presentation of results</td>
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<tr>
<td>8. Redesign</td>
<td>8. Develop new hypotheses</td>
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</tbody>
</table>

EiE (Engineering is Elementary) [3] is an inquiry-based STEM curriculum that teaches students a variety of skills including problem solving and thinking skills and it is built around and engineering design process. It is developed by the Museum of Science in Boston and proposes a simple five-step Engineering Design Process to guide students, especially children at a young age, through any engineering design challenges. Figure 1 presents the Engineering Design Process which is a flexible cycle without a start or an end point. Anyone is able to begin with any step from: a) ASK (a problem is faced), b) IMAGINE (brainstorming solutions), c) PLAN (diagram and materials), d) CREATE (follow the plan or test it), and e) IMPROVE (changes and modifications).

According to [5], implementing teaching strategies, like problem-based learning within a STEM curriculum, may enhance students’ desire to understand the world around them and engage them in classroom instruction. Skills like problem solving, literacy, creativity, and motivation are positively influenced when children access
technology in their learning environments. Also, using technology as an instructional tool enhances children’s learning and educational outcomes [19]. According to Resnick [21] considering technology not only as a supporting tool, but mainly as a creative tool for current teaching methods offers children the opportunity to evolve as creative thinkers and explorers who plan, analyze, and share their work collaboratively.

STEM education is described as a center of integrated disciplines, as an interdisciplinary bridging among discrete disciplines or as an entity [13]. Sanders states that the “notion of integrative STEM education includes approaches that explore teaching and learning between/among any two or more of the STEM subject areas, and/or between a STEM subject and one or more other school subject.” [23].

The early education system needs to shift from fearing STEM to playing with it. Teachers in the preschool or the early education system are probably already applying parts of STEM in everyday basis without realizing it. It is the educators’ responsibility to work with children during these early years by using educational appropriate strategy and playful approaches to foster STEM skills [26].

According to Hunter [7] children must develop an interest in STEM at a young age to excel at them when they are older. Researchers and policy-makers have pushed for an increased focus on STEM in early childhood. Research, also, has highlighted the importance of exposing young children to STEM in an early age in order to avoid stereotypes or other obstacles to enter STEM fields in later years [4, 9].

Finally, robotics as a tool can help make abstract ideas more concrete. Children can directly view the impact of their programming commands on the robot’s action. Children who work with robots can move around the room, work on the floor or a table, and act out with their own bodies, before programming the robot. Robotics becomes a new early childhood useful educational mean of the 21st Century [25].

3. Goal setting activities

The proposed activities concern teaching the notion of speed in Kindergarten by utilizing the programmable robot “Sphero SPRK” (http://www.sphero.com/) (Figure 2). Sphero is a remote-controlled robotic ball, designed by Orbotix. It is capable of moving around in any direction and in various speeds. In this paper the Lightning Lab application which runs on a tablet is proposed to be used in order to program Sphero’s movement. Specifically, the introduction of Sphero in the Kindergarten classroom is suggested, following the implementation of two additional activities in which children take action with their bodies. The activities have been designed within the context of a postgraduate thesis, still in progress, and will be implemented in early-December, 2016.

Figure 2. Sphero SPRK
In the first activity, children will realize that the faster competitor in a fixed-distance race is the one who needs the shortest time to reach the finish. Through this activity children are required to solve a problem that animals living in a forest face. Specifically, they need to know the winner of a race among them with a designated, common start and termination point. Thus, children should be able to search for an answer to questions like “Who is the winner if the distance is the same?”,” “Who finishes first?””. In order to achieve that, children will be required to organize their own race. The researchers will guide the activity introducing two important tools, the chronometer and a measuring instrument for distance which will be decided together with the children after an in-class discussion (it can be a ribbon, a stick or anything they choose). The chronometer is designed in the Scratch environment (http://scratch.mit.edu/) and uses both numbers written on a PC screen and verbal representation. Additionally, hand-claps will be used to count time with the help of chronometer. Children will be requested to run individually or in dyads, while the others count their time using hand-claps and all together will collect and write down the data related to the time each child needs to reach the finishing point, on a board. At the end of the activity, children will be requested to compare their collected data and decide which one of the competitors is faster, but also to justify their answer.

In the second activity, it is expected that children will realize that the faster is the one who covers the longer distance in the same period of time, as the others. More specific, children will be confronted with another problem that the animals face. “What if we race without having a distance limit, a specific route? Who wins then?””. Children need to design a different race in this time case. They will be challenged to cover (run/walk) a non-limited distance in a certain amount of time. They run individually and/or in groups. When the time ends, they will be asked to place custom-made sing with their name on the floor, next to their feet and measure the distance with the measuring instrument they will have already agreed upon, at the beginning of the intervention. Individually they will be asked to collect and note their data (distance). At the end of the activity, the children will be requested to compare their data with each other’s and decide, also justifying their conclusion, who is faster.

Children in both activities will have to work with the notions of distance and time, while trying to find out and justify “who is faster or slower”. For reaching an understanding and formulating their answers, children will be required to organize and compete in their own races as aforementioned. Through the last activity it is expected that a strong representation for speed will be acquired by the children, who will connect the terms “faster” and “slower”, which they are already familiar with at this age, with the notion of speed. In this activity, an attempt will be made to introduce the notion of speed related to “how fast someone or something moves”, with Sphero SPRK. Children will be able to program Sphero’s speed through a tablet, using an application called “Lightning Lab” (Figure 3a) and see in action what happens if Spheros’ speed is altered. Moreover, the researchers will introduce the notion of speed in terms of “faster” and “slower”. The researchers will highlight that “the notion of speed, according to scientists, is how fast an object moves. If someone or something is faster than someone or something else, this means that his/its speed will be higher”. In order to examine this statement, children will be introduced to Sphero, “a tool that scientists use to examine speed”. A scientific experiment is planned to take place in the Kindergarten, using Sphero, utilizing the new knowledge of speed from the previous activities. Sphero will be controlled by children, through the Lighting Lab application, using a scale made by the researchers which utilizes
different animals in order to make it easier for children to understand speed through metaphorical representation (the animals can be easily ordered according to how fast they are) (Figure 3b). Children will control the speed of Sphero recognizing the five-scaled representation using 1 for the lowest and 5 for the highest speed. The researchers use animals as well as numbers in an appropriate redesigned environment (using stickers on the screen of the tablet) in order to make it easier for children to understand speed grading. Children will organize with the support of the researchers two experiments with Sphero: a) Sphero covers same distances with different speed, and b) Sphero covers different distances in a same amount of time. Through this activity children will be able to recognize: a) when the speed of Sphero is higher the designated distance is covered faster (experiment a), and b) when the speed of Sphero is higher it covers longer distances in the same amount of time (experiment b).

![Figure 3. Lightning Lab – Speed](image)

4. Discussion

With the proposed activities, it is supposed that children will approach an understanding of the notion of speed. They should be able to not only define which of two objects/behings is faster, but also to predict which will be faster if we know the speed of the two objects. In addition children should reach an understanding of how fast an object is, using its speed as a justification approach.

The core idea of the proposed intervention is that an empirical experiment will take place in the third activity, involving the Sphero. By setting its speed, they will be able to observe how fast it is. Through the first two activities, the children will work with
notions they are already familiar with at this age; time and distance. They will be facilitated to connect them with the terms “faster” or “slower”, which they also are familiar with. In an attempt to reinforce their perception, the race setting has been designed, also supported by questions like “who will finish first” and “who covered the longer distance”.

Through the third, experimental activity, the children will be required to apply their perceived knowledge from the first two activities in order to attempt to understand the notion of speed. The research hypothesis is that they will be able to understand that speed is connected to how fast someone of something is, that speed is connected to distance covered and time required to do so. At this stage it is not easy to predict how well they will perceive the notion of speed, but if the connection among the core constituents can be made (speed, time, distance), the intervention will be considered as successful. The children are not ready to understand the mathematical relation between those elements, so an understanding that there is a relation and an empirical recognition of “who/what is faster than the other” will be considered as adequate for this age, since speed is not being discussed at such young ages.

By evaluating the study implementation, the researchers plan on being able to determine the children’s readiness to understand the designated notions and identify the element which facilitates this understanding more (animal representation, race setting, facilitating questions, etc). The latter will be evaluated through semi-structured interviews with the children and observations. The results will determine future research paths for the same or similar notions in the science field.

5. References