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Is my Frog Faster? A Race at Home

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Abstract**:** This article introduces a play-based activity that aims to assist pupils to primarily appreciate the concept of speed. An integrative STEM education approach was adopted in determining the objectives of the study. The activity particularly aimed to improve skills in using tools and materials strategically, collecting data, reasoning abstractly and quantitatively, and describing the logical connection between distance and time. An authentic learning environment was created. Two pupils with the assistance of their parents built, colored, and participated in a jumping frog contest. During the contest, they measured distances and time intervals, created a data table, and discussed and calculated the speeds of various frogs. In every action, the pupils were asked to focus on particular aspects of the activity setting. They initially focused on how to fold a paper frog, which was the first contextualizing action where they have seen the connection between scratch paper, folding, and a jumping frog. Next, they were asked to focus on race where they realized the connection between measuring distance, taking time, and creating a data table. In the last contextualizing action, in the process of determining the champion, they recognized the relationship between distance, time, and speed.
Keywords: Activity, Integrative STEM education, Play-based, Speed

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Introduction

Teaching Philosophy

Vygotsky (2016) sees play a leading activity in the cultural development of the child. To him, development begins on social (inter-psychological) plane as actual relations between child and adult and then transforms into individual's mental functioning ona psychological plane (Ibid, 1978).Meaning-making is thus a social process (Wertsch, 1991) rather than a psychological one. Inspired by the works of Vygotsky (1983, 1993), van Oers (2001) viewed the attainment of higher mental functions (abstraction) as a discursive process of taking a point of view and progressively focusing on particular aspects of an activity setting, a concrete situation. Van Oers named this process contextualizing action. In this action, through focusing on particular and increasingly isolated elements of the setting, the learner begins to realize how those elements that were not thought to be related to each other were actually related (Saglam, 2015). This action is similar to child-mother interaction (Rogoff, 1990). In the present paper, we believe that a meaningful understanding of "speed" could be developed, in the context of a play, by having children participate in several embedded situations addressing distinct skills and understandings where children get an opportunity for building, observing, measuring, recording, computing, communicating, and reasoning abstractly and quantitatively.

Integrative STEM Education

In determining the objectives of the activity, integrative STEM education approach (Sanders, 2009) was adopted. Unlike traditional S.T.E.M. education, in which each discipline is taught disconnectedly, integrative STEM education combines two or more STEM disciplines. It integrates concepts and practices of science and/or mathematics education with those of technology and engineering education. By participating in an integrative STEM learning environment, students likely acquire not only technological or engineering concepts but also those from mathematics, science, and/or art.

Learning Objectives and Connection to NGSS & CCSS

Table 1, 2 and 3 shows objectives and connection to NGSS & CCSS.

Table 1
Learning Objectives

Students who demonstrate understanding can;
• select appropriate materials to build the fastest frog • design/build the frog by folding and colouring • differentiate relative sizes of such units like m, cm, min, and sec. • use tools and materials strategically to measure the distance and time • measure properly distance and time in SI units • create and fill in a data table • analyze and interpret data to make sense of phenomena • reason abstractly and quantitatively • describe the rational connection between distance and time • solve related problems from different contexts

Table 2
Connection to the Next Generation Science Standards (NGSS Lead States 2013)

Dimensions	Classroom Connections
Science and Engineering Practices	(1) Analyze and interpret data, (2) Use mathematics and computational thinking, (3) Construct explanations (for science) and design solutions (for engineering), (4) Obtain, evaluate, and communicate information.
Disciplinary Core Ideas	Not included
Crosscutting Concepts	(1) Patterns (2) Scale, proportion, and quantity

Table 3
Connection to the Common Core State Standards (NGAC and CCSSO 2010)

ELA-Literacy Describe the relationship between a series of historical events, scientific ideas or concepts, or steps in technical procedures in a text, using language that pertains to time, sequence, and cause/effect.
Mathematics Reason abstractly and quantitatively; use appropriate tools strategically.

The Concept of Speed

In order to measure how fast an object was determined by the concepts of speed or velocity (Hewitt, Suchocki & Hewitt, 1999, pp 12-19). Both terms refer to the rate that an object covers in a period of time. Yet, there is a distinction between the two concepts. Velocity is a speed in a certain direction, but speed indicates how fast an object is moving without any concern about its direction. Unlike velocity, speed is a scalar quantity, a magnitude or numerical value not depending on object's direction. An object with a high speed covers a large distance in a short period of time. On the other hand, an object with a zero speed indicates no motion at all. Distance is also a scalar quantity and a measure of the length of the path the object takes regardless of its direction. For long distances, kilometers per hour (km/h) and, for short distances, meter per second (m/s) or centimeter per second (cm/s) are used. The speed that an object has at any instant is called instantaneous speed, which is, for instance, the one depicted by the speedometer of a car at a particular point in time. However, objects rarely move at constant speed. Average speed is generally spoken. It does not take the speed variations into account including stops. In the present activity, the average speeds of frogs are determined using the following formula:

$$Average\ speed\ =\ \frac{Distance\ (cm)}{Time\ (s)}$$

The Activity

On Covid-19 lockdown period, children were unfortunately trapped in their rooms and kept out of formal education. This brought us to think of and design a play-based activity that could easily be carried out by parents at home and, of course, by teachers in the classroom. The present activity aimed to help pupils appreciate the concept of speed. Accordingly, aplay-based activity was designed and two children, a fifth grader (11 years old, boy) and a fourth one (10 years old, girl), participated in the play. Children played with their own parents at their own homes.

Step 1. Building a Jumping Frog

The activities started with building a paper frog. The paper frog is able to jump pretty far if it is pressed on its back. How far it can jump depends on many variables such as size, paper type, stiffness, folding quality, and so forth. A colour or ordinary paper, scissors, and crayons are the primary materials necessary in constructing paper frogs. In order to build one, sitting on the floor with their children, the parents initially carried out an online search with a key word, "origami jumping frog", and a number of related videos came forward. The parents choose the one that had seemed easy to grasp and track. They watched and followed the directions in the video.

By cutting the edges of the paper, folding it up and down, shaping the legs, and coloring, the children and their parents eventually ended up with a number of good-looking frogs. Yet, this process was not as easy as expected. The children were not always able to follow all the directions without parent assistance. In such cases, the parents stopped the video, explained, and showed their child how to fold. It seemed following all the directions in the video was a difficult task for the children. Furthermore, every time the children fold the paper, because the paper gets thicker, folding became harder. On the other hand, it was seen that the children got much better in building the frogs every time they construct one. When the frogs were ready for competition, the children were asked to color them. According to children, this was the most fun part.

Safety consideration

Before the activity, parents must alert their children to the dangers of improper use of scissors. Injuries could be prevented by taking such simple precautions as (1) informing children about how to use scissors safely,(2) using them for the only intended purpose, (3) working in well-lighted areas, (4) focusing merely on the task, (5) ceasing to use the scissors when something distracts, (6) insisting on cutting paper in a direction away from their fingers, hands, arms, and body, and (7) urging them not to run around with scissors on hand. Image 1-6 shows building steps of the frogs.

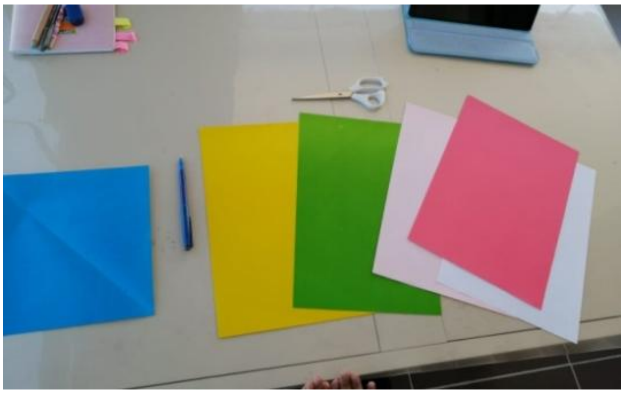

Image 1. Ready for building up frogs

Image 2. Cutting the edges of the paper

Image 3. Folding the paper up and down

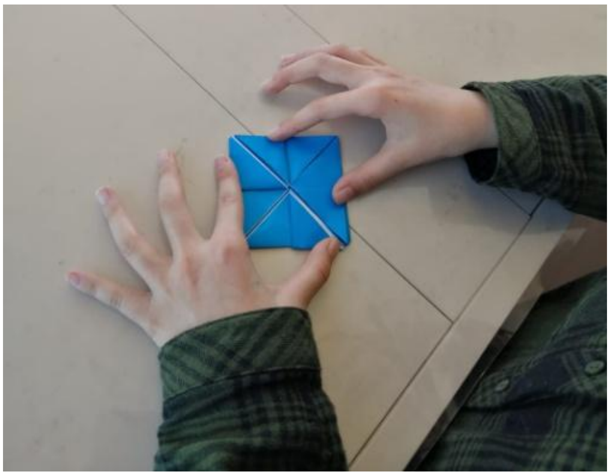

Image 4. Forming the legs

Image 5: Coloring the frog

Image 6: Frogs are ready for a race

Step 2. The Contest

A detailed plan for the activity was made before the race. If each racer was given the same duration, the champion would be the distance with the most progress. On the other hand, if each competitor was given the same distance, the champion would be the one that finished the race as soon as possible. In either case, the concept of speed would not be required in determining the champion. Therefore, it was decided to give the racers differing durations. Before the race began, a start line was drawn on the floor. Frogs competed one after the other, not simultaneously. When the time given was over, the distance covered was measured in cm. Image 7 shows this measuring activity.

Image 7. Measuring the distance in cm

The children then created a data table. Image 8 shows this building activity.

Image 8. Creating a data

Below is the data from one of the families.

Racers	**Time (s)**	**Distance (cm)**
Blue Frog (The Child's frog)	30	380
Green Frog	20	220
Yellow Frog	10	195

The parent then asked his son, "Who is the champion?" pointing to the table above. The child said that he would be the champion because the distance his frog covered was the lengthiest. However, his older brother and the parent objected and claimed that the time intervals were not the same. Then, the child offered to calculate the distances covered in 10 seconds. In order to do that, they divided distances by 3, 2 and 1 respectively. 380/3, 220/2, and 195/1 giving the distances covered in ten seconds. To the child, the frog jumping the most distance in ten seconds would be the champion. The parent found that idea quite reasonable and accurate and offered him finding out the distance in one second instead. They all agreed on this idea. Then, they carried out the following computations:

$$Bluefrog = \frac{380\ cm}{30\ s} = 12{,}7\ cm/s$$

$$Greenfrog = \frac{220\ cm}{20\ s} = 11\ cm/s$$

$$Yellowfrog = \frac{195\ cm}{10\ s} = 19{,}5\ cm/s$$

They then rounded off the numbers to two significant figures and got 13, 11, and 20 cm/s. They reached the conclusion that yellow frog was the champion. Thereafter, the parent said that the distance taken in one second is called **speed** in science. The parent further asked him three supplementary problem-based open-ended questions. Gladly, he was able to solve them all without the parent assistance. Table 4 displays questions that students are expected to respond before, during and after the activity.

Table 4
Higher Order Guiding Questions

Before, during, and after the activity students are expected to respond:
• What are the advantages and disadvantages of selecting materials (types or sizes)?
• How can you decide which tools could be used to measure distance and time?
• How is meter connected to cm?
• How is minute connected to second?
• How can you measure the distance that frog has covered?
• How can you measure the time taken by frog?
• How would you determine the fastest frog?
• How is distance connected to time?
• How would you explain zero speed?
• How would you explain the fastest?
• How would you explain the difference between a slow and fast object?
• How would you explain when an object's speed is 70 cm per second?
• How would you find the distance if aforementioned object moves fifty seconds?

Conclusions

The activity created meaningful embedded contexts. Each context addressed distinct skills and understandings. Searching on the web for paper frog origami (technology), building and coloring the frogs (engineering and art), measuring distance, taking time, collecting data, and creating a data table (math), and computing, communicating, and discussing the speed of frogs (math, language, and science) addressed the important elements of integrative STEM education. In every contextualizing action, the pupils were asked to focus on particular aspects of the activity setting. They initially focused on how to fold a paper frog, which was the first contextualizing action where they have seen the connection between scratch paper, folding, and a jumping frog. Next, they were asked to focus on race where they realized the connection between measuring distance, taking time, and creating a data table. In the last contextualizing action, in the process of determining the champion, they recognized the relationship between distance, time, and speed. Table 5 depicts an assessment tool for evaluating students' performance.

Table 5
Frog Activity Performance Assessment

Analytic Rubric
Frog Activity Performance Assessment

Category	Beginning (1)	Developing (2)	Accomplished (3)	Score
Preparation	No or only one material/tool is present and ready to use	At least two materials/tools are present and ready to use	All materials/tools are present and ready to use	
Designing	The child was not able to complete the frog on her/his own. The parents built all/some part of it	The child completed the frog with the help of his/her parents	The child completed the frog without any help	
Measuring	The child was not able to measure time and distance and asked for help from his/her parents	The child was able to measure time or distance properly without the help of his/her parents	The child was able to measure both time and distance properly without the help of his/her parents	
Collecting Data	The child was not able to fill out the data table on her/his own	The child was able to fill out some parts of the data table properly	The child filled out the data table completely and properly	
Computing	The child was not able to calculate the speeds of the frogs and asked for help from his/her parents	The child was able to do some parts of the calculation properly without the help of his/her parents	The child was able to do the calculation properly	
Transferring	The child was not able to calculate the related problems and asked for help from his/her parents	The child was able to do some parts of the calculation properly without the help of his/her parents	The child was able to do the calculation properly	
			Overall Score	

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