The Effect of STEAM Education on Elementary School Student's Creativity Improvement

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Abstract. Lately, education on convergence and invention from the perspective of cultivating ingenious talents is becoming increasingly critical. The time has come for us to establish goal and content structure of convergence education based on its theoretic framework and link it with various contests on creativity education to promote innovative convergence and invention education at schools. This paper aims to establish the theoretic framework of convergence education based on education activities using Rube Goldberg Machines both home and abroad, identifying its link with invention education at schools and educational benefits to eventually examine if they do contribute to boosting creativity.

Keywords: STEAM, Rube Goldberg, Elementary education, Creativity.

1 Introduction

Simply put, the 21st century is epitomized as knowledge-based society founded on digitalization. Knowledge-based society should focus more on developing individuals' diversity and creative talents capable of producing unique, practical and intelligent values rather than merely growing technicians or intellectuals. Lately, education on convergence and invention from the perspective of cultivating ingenuous talents is becoming increasingly critical. The time has come for us to establish goal and content structure of convergence education based on its theoretic framework and link it with various contests on creativity education to promote innovative convergence and invention education at schools.

Rube Goldberg's Invention requires various inputs and efforts ranging from scientific knowledge, mathematical reasoning, engineering design, to ability for technical operation. It can be an ideal activity for STEAM education that stands for science, technology, engineering, art and mathematics. In this regard, the study

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identified elements of Rube Goldberg's Invention that could be applied to STEAM education. The basic idea of Rube Goldberg's Invention is to design the most complicated mechanism to solve the simplest problem. This process involves scientific principles, mathematical intuition, engineering maneuver, creative design and skills. It has all the elements that STEAM education aims to instill in students. This study compares the mechanical elements of Rube Goldberg's Invention with ideas of STEAM, in order to design learning materials that can be introduced to school curricula.

This paper aims to establish the theoretic framework of convergence education based on education activities using Rube Goldberg Machines both home and abroad, identifying its link with invention education at schools and educational benefits to eventually examine if they do contribute to boosting creativity.

2 Mechanical Mechanism of Rube Goldberg Machine Contest

Mechanical mechanism of Goldberg Machine can be better understood with rolling ball, which can be the matrix of Rube Goldberg Machine.

2.1 Lifts

Lifts refer to electric elevators to ascend. They generally raise beads to gain high potential energy. Automatic operation in a rolling ball usually relies on electric machines and both coil-type and chain-type lifts are used as shown in [Fig.1 - left]. Coil-type lifts do not occupy large space but are rather slow while chain-type lifts occupy larger space but are faster. Both can be rotated manually but automatic operation requires the use of electric motor. [Fig.1-right] is a drawing indicating ways to boost potential energy without the use of such electric energy. Collision of descending balls with domino incurs impulsive force and thus switches kinetic energy into potential energy.

![Fig. 1. (Left) Coil-type lifts and chain-type lifts, (Right) Drawing](image)

2.2 Track Switches

[Fig.2-left] is a machine relying on lever principle or ball weight to switch ball's track. It is a mechanical element switching ball's direction as a foot bridge crossed to take a
new track. It helps balls to take different moves by guiding them to different directions as they come. [Fig.2-right] is a drawing including elements of the proposed track switch. When the descending beads hit ④ golf ball, the ball takes on three different moves. First, it falls into the cup in 'A' and the switch plays music. The descending ball is then sent to 'B' direction to cause water overflow and holds on to the string attached to pulley in 'C' to raise the stick up.

Fig. 2. (Left) Track Switches, (Right) Drawing

2.3 Bounce

[Fig.3-left] is a mechanical mechanism using elasticity to help the ball fall, bounce and jump to another direction. Sending the ball to the precise target direction requires hundreds of tests. Generally, metal is used for durability but elastic materials like leather and rubber string were used in Creativity Olympiads. [Fig.3-right] is the proposed drawing using rubber string for bounce. Goldberg Contests in general do not have many bounce machines because it is extremely challenging to hit beads' bounce angle and height.

Fig. 3. (Left) Bounce, (Right) Drawing
2.4 Loops

As presented in [Fig.4-left], loops, which are rails that create a vertical roller coaster, reverse potential energy and kinetic energy to either help the ball jump to the air or rotate while riding on the rail to support various moves. [Fig.4-right], which is the proposed drawing, enables ⑨ to serve as a loop to jump the falling ball.

Fig. 4. (Left) Loops, (Right) Drawing

2.5 Coils

[Fig.5-left] is a machine in which the ball descends via horizontal circular wire and enters into rotational motion in centrifugal force tunnel to switching potential ZA energy into kinetic energy with centrifugal force. Speed of the ball spinning downward when seen from above is slow but it holds a strong kinetic energy. [Fig.5-right] is part of the proposed drawing. The red circular part bends like a coil and rotates to switch potential energy into kinetic energy.

Fig. 5. (Left) Coils, (Right) Drawing
2.6 Collectors

[Fig.6-left], which is the collector in "Dream Runner" temporarily locks up balls before they are sent altogether when balls' weight or height meet certain conditions.

[Fig.6-right], which is the proposed brain lightening drawing, shows three beads descending from ② cup and two of them dropping into ③ cup before one last one falls down. When the descending bead pushes ③ cup stand, the remaining two beads become the collector by descending with a time interval.

3 Education Impact of Rube Goldberg Machine

First, the educational impact of Rube Goldberg Machine when applied to contests and invention education programs is highly significant. Individuals need to cater to their imagination and creative ideas to go through the whole process to make Rube Goldberg Machine required to complete their mission. Furthermore, close communication among team members and creative thinking ability are prerequisites to come up with problem-solving ideas.

Efforts to design Rube Goldberg Machine and to devise each element can build design skills, invention capability and eventually engineering skills driven by creation activities based on a comprehensive scientific principles and mechanical mechanism. Individuals will subtly but surely develop themselves into a creative talent while going through the process of making Rube Goldberg Machine as such.

Second, the entire process of making Rube Goldberg Machine goes a long way in character education. The very act of preparing to deal with the 「challenging mission」 and participating in a contest build creativity, challenging spirits, teamwork, pioneering spirits and reform-driven mind set. Efforts to make the most ingenious and effective work in a given environment bring out concentration, patience, adherence, sense of focus and team activities are associated with integrity, autonomy, leadership and care for others.

Third, it is also highly effective in nurturing creativity. Team members work together to solve a 「challenging mission」. The whole process from design to material selection based on the design and making a mechanical mechanism founded
on scientific principles require creative thinking. In the course of making Rube Goldberg Machine through a solid teamwork, members build their design skills, improve invention activities and ultimately learn to create and grow into a talented engineer.

Fourth, having Rube Goldberg Machine in a school curriculum and part of invention class program would make for a highly effective and exciting education. Students in classes that made Rube Goldberg Machines expressed keen interest in and engagement to the class and team members eagerly shared opinions and views on the existing mechanical mechanism and scientific principles. In particular, students were able to have a better grasp of the link between a scientific principle and actual output by presenting the scientific principles at class.

In short, a new trial to make Rube Goldberg Machines as a project class in invention class programs, science class or engineering class would be a great opportunity for students to have a hands-on experience.

4 Conclusion

This paper would like to make a few proposals based on the study. First, Rube Goldberg Machine deserves to be included in school invention education and curriculum considering its advantages and educational impact. Scientific principles, mechanical mechanism, design and implementation that all need to be examined in the process of making Goldberg Machine can aid creativity education in science, art and engineering.

Second, structure of the new school invention education combining characteristics of Rube Goldberg Machine should be applied to schools. Creative invention programs that students prefer to take should be applied to regular school curriculum and should be given due attention they deserve.

Third, concrete procedures should be in place. Audio-video textbooks in class for a better understanding and display of actual output before design will help students to make something that is more real and creative. Being such, follow-up studies should give more attention to class procedures and theoretical structure.

Fourth, a clear theory on Rube Goldberg should be established for use as basic material to develop invention education course in schools. Also, researchers should be given opportunities to participate in Rube Goldberg Machine Contest in developed countries for a more concrete study.

Fifth, video clips like UCC and basic materials promoting Rube Goldberg Machine should be made available and sent to invention classes and schools.

Sixth, Rube Goldberg Contest should be upgraded to a global level so that it can be a venue to identify and nurture creative talents capable of leading the knowledge-based society in the 21st century.

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