



Projectile Horizontal and Vertical Component of Motion Independence Demonstrator

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Abstract

This paper developed an instructional tool called Projectile Horizontal and Vertical Component of Motion Independence Demonstrator, user manual, and learning module to physically demonstrate the projectile motions' abstract concept. Specifically, it was pursued to develop an instructional tool, user manual, and learning modules on projectile motion, determine its evaluation results from the experts, and determine recommendations drawn from the evaluators for the improvement, utilization, and dissemination of developed instructional tools and learning modules. Quantitative and qualitative data were gathered using a four-rating Likert scale evaluation sheet. Results showed that instructional tool and user manual are "very satisfactory" and suggestions for improvement, utilization, and dissemination of the instructional materials are forwarded. Further, it is recommended for replication and use in secondary school as instructional material.

Keywords: Projectile motion, Instructional tool, User manual, Learning modules

Introduction

Science education particularly the physics area is considered one of the most challenging subjects offered in a school curriculum. Hence, it is very essential for it explains the basics of living and helps people make sense of the world. However, science education in the Philippines cannot be considered a strength. Pursuant to 2014 statistics, the National Achievement Test (NAT) pass rate in science for sixth grade is only 69.21%, while the high school pass rate is much worse at only 46.38% (Ambag, 2018) [1]. This indicates that the field of science teaching in the country is relatively small and that improvements are required.

In 2018, the Programme for International Student Assessment (PISA) conducted by the Organization for Economic Co-operation and Development (OECD), ranked the Philippines last in all three areas of

assessment which are Reading, Mathematics, and Science. In science literacy, the average score for the Philippines was relatively low gaining only 357 versus the OECD average of 489. The result shows a call for the education system to be reviewed, to know the different possible causes whether it affects the new (K-12) curriculum, the teacher's and student's readiness or unpreparedness in this assessment, or other possibilities like strategy in classroom instructions [2].

As science seeks to create simple descriptions and explanations for the complexity of the world, a scientific model is considered a powerful tool and a common way to represent these simplifications. From the perspective of Oh and Oh (2011), the purpose of a scientific model is to describe, explain, and predict natural phenomena [3]. According to Treagust, Chittleborough, and

Mamila (2002) [4], Models are useful tools in learning science that can be used to improve explanations, generate discussion, make a more valued prediction, provide visual representations of abstract concepts, and generate mental models,.

In grade 9 physics, one of the relevant topics is Projectile Motion. Giancoli (1980: 53) defined Projectile motion as the motion of an object that is projected into the air at an angle, near the earth's surface (McCloskey, 1983). For instance, a ball dropped from the top of a table and another ball rolled on the table which takes a horizontal distance while it drops, will reach the ground at the same time as long as it leaves the table simultaneously. The vertical distance (d) of the two ball is the same, and the acceleration due to gravity (a) is constant at 9.8 m/s^2 . This shows that even if the ball rolls off the top of the table and then take a horizontal distance as it drops, it will take the same time to reach the ground with that of the ball that straightly falls. The fact that one ball is moving horizontally while it is falling does not affect its vertical motion, according to Halliday and Halliday (2001: 56). Unfortunately, this concept of projectile motion is misunderstood by many and is a source of a lot of misconceptions of students [6].

To address this problem and uplift the science education curricula, an instructional tool called Projectile Horizontal and Vertical Component of Motion Independence Demonstrator can be designed, developed, and used in order to challenge and hopefully change students' misconceptions and problems related to projectile motion. Through this prototype, students will be given a chance to manipulate the model for them to learn and understand first-hand the concept of projectile horizontal and vertical component of motion.

This demonstrator was combined with learning activities by creating a module to target the required competency in studying projectile motion. The developed instructional tool and learning module will aid in providing 4 substantive discussions

and explanations of projectile motion in the classroom. This will allow teachers to teach projectile motion while avoiding misconceptions that students may have.

Methodology

This descriptive-development study gathered data from the evaluation of experts in the field of science teaching. The researchers utilized an evaluation form adapted from the two sets of four-rating scale evaluation from the issued evaluation sheet of the Department of Education for Learning Resources Management and Development System (LRMDS) and from the Learning Resource Evaluation Guidelines of the Saskatchewan Ministry of Education (2020). The researchers randomly selected science expert teachers in five schools around the Division of Camarines Sur during their school meetings and on an appointment basis. Demonstration of the device functions was done face to face to facilitate proper evaluation. The time of demonstration and evaluation of the instrument for each set of teachers varies from different schools depending on questions, clarifications, and discussions with demonstrator and evaluator. The results of the evaluation were measured using frequency and weighted mean. The learning module was also evaluated and validated by selected secondary school science teachers on a scheduled and appointment basis.

Results and Discussion

The present study primarily aims to devise an instructional tool to discuss selected projectile motion concepts. *Projectile Horizontal and Vertical Component of Motion Independence Demonstrator* was the designed and developed instructional tool to aid instruction in Physics, discussing two projectile motion concepts, namely horizontal and vertical motion and projectile at an angle. The instructional tool was consisted of five main features as shown in Figure 1. The main feature of the instructional tool is to show the independence between the horizontal and vertical

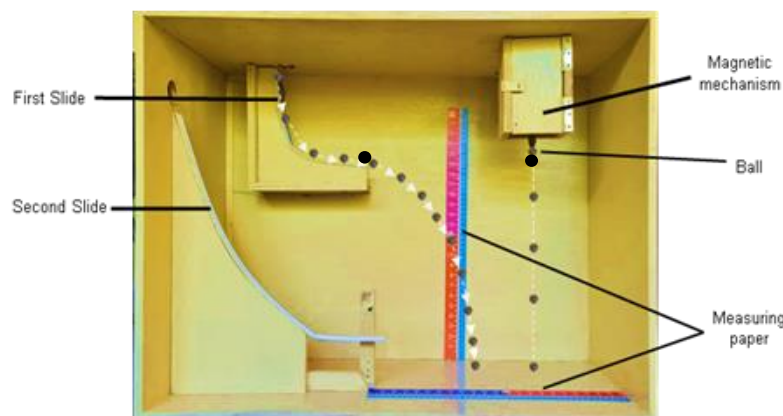
component of motion. Magnetic mechanism allows a magnet of the ball to demonstrate the independence of the projectile's horizontal and vertical component of motion. It was made using the concept of a simple electrical circuit. A positive electrical charge wire that was attached to a battery goes through the switch at the back of the frame, then it was coiled to an iron screw to create a magnetic mechanism.

The positive charge electrical wire was connected to a trigger at the tip of the first slide, allowing it to cut the power supply when the ball passes through it. When the ball having horizontal motion was launched, it

should demonstrate that it would reach the ground at the same time as the ball having a vertical motion only.

A user manual prepared by researchers was developed along with the instructional tool to help students and teachers to use the instructional tool and avoid the risk of accidentally damaging the developed instructional tool, thereby reducing repair costs and avoiding unnecessary repairs. The user manual's contents are information regarding the background of the instructional tool, how to set up the instructional tool, troubleshooting and maintenance, and safety measures of using the instructional tool.

Figure 1. *Projectile Horizontal and Vertical Component of Motion Independence Demonstrator*



The instructional tool was examined carefully on three (3) factors using a likert-scale type of instrument ranging from 1 to 4 where 4 being Very Satisfactory (VS); 3 - Satisfactory (S); 2 - Poor; and 1 - Not Satisfactory. Table 1 beneath suggests the precis of evaluation by the respondents at the instructional tool. In the design factor of the instructional device, the overall score was 3.86, defined as “very satisfactory”. In terms of the instructional quality factor of the tool, an average rating of 3.75 was obtained having a description of “very satisfactory”. Lastly, on the cost-benefit, the overall rating

is 3.80 with a description of “very satisfactory”. Henceforth, the grand mean on evaluation of the respondents to the instructional tool is 3.80 and has a description of “very satisfactory”. The overall evaluation indicates that the respondents evaluated the instructional tool is effective for use in teaching physics concepts in Projectile Motion in public and private secondary and tertiary institutions.

Table 1. Summary of expert's evaluation on the instructional tool

Factors	Average Mean	Description
Design	3.86	Very Satisfactory
Instructional Quality	3.75	Very Satisfactory
Cost-Benefit	3.80	Very Satisfactory
Grand Mean	3.80	Very Satisfactory

The learning modules were also developed to complement the instructional tool as shown in Figure 2. The learning modules consist of two developed parts: Module 1 deals with "Motion in Two Dimensions: Horizontal and Vertical Motion" and Module 2 with "Motion in Two Dimensions: Projectile at an Angle". The lessons included in the learning module have been designed to fit within the framework of the science curriculum and

the standards and Most Essential Learning Competencies (MELCs) in the K-12 science curriculum required by the Department of Education, particularly in the 9th grade. The content of module 1 was discussion on the independence of horizontal and vertical projectile motion while module 2 covers the relationship between the angle of projection and the height and range of the projected ball.



Figure 2. Front Cover of the Learning Module 1 and 2.

Also, the Department of Education (DepEd) of the Philippines' 4-point evaluation rating sheet for print resources was used to evaluate the crafted module with two (2) as the lowest rating on very few criteria and four (4) as the highest rating in most of the criteria. Table 2 below shows the summary of the overall evaluation of the respondents on the crafted learning module. The results were as follows: the average mean for the content is 3.89; for the format, the average mean is 3.82;

the presentation and organization criterion, the average mean is 3.89; and, on the accuracy, and up-to-datedness of information in the learning module, the average mean score is 3.83, all described as "very satisfactory". The grand mean of the respondent's evaluation of the learning module was 3.86 and got an overall rating description of "very satisfactory".

Table 2. Summary of experts' evaluation on the learning module

Factors	Average Mean	Description
Content	3.89	Very Satisfactory
Format	3.82	Very Satisfactory
Presentation and Organization	3.89	Very Satisfactory
Accuracy and Up-to-Datedness	3.83	Very Satisfactory
Grand Mean	3.86	Very Satisfactory

For further development of the instructional tool, recommendations drawn from the evaluators are considered. The recommendations of the evaluators on the improvement of the instructional tool includes incorporating other necessary materials, proper labelling of measurements in the tool, maximizing the background, modification of instructional tool's size, changing the colors of the background and metal ball, and modification of the materials used. For the utilisation of the instructional tool, the evaluators recommended confirming the user-friendliness of the instructional tool and including proper storage for the metal ball. The recommendations of the evaluators on the dissemination of the instructional tool includes creating video tutorials on the tool's development, securing DOST approval, proposing usage of the instructional tool in public school, and subjecting to second evaluation of the improved instructional tool

On the other hand, the recommendations drawn from the evaluators on the improvement of the learning modules include adding more learning activities and providing key-to-correction of the learning module. It was found out that there were no recommendations from the evaluators on the utilisation and dissemination of the learning modules.

Conclusions

In conclusion, the developed instructional tool and user manual in teaching projectile motion concepts is completed and ready to be

utilised for teaching. Furthermore, it met all the prescribed requirements set by the Department of Education for developing improvised instructional materials and is able to show the independence of motion of the projectile in its horizontal and vertical axis. On the other hand, the crafted learning module met all the minimum requirements set by the Department of Education for developing printed materials to be utilised in teaching projectile motion, particularly the independence of the horizontal and vertical component of motion. The recommendations of the evaluators on the improvement, utilisation, and dissemination of instructional tool and learning module were found varied and can be easily adapted for improvement of the tool.

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