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Project MC^2: Raising Students' Procedural Fluency along Concepts of Forces and Motion

Michael C. Bagay[1], Windsor A. Eugenio[2], Ma. Victoria C. Soriano[2], Romiro G. Bautista[1,3,*]

[1]College of Teacher Education, Quirino State University, Quirino, Philippines
[2]Quirino General High School, Department of Education, Quirino, Philippines
[3]Office of the University Director for Instruction, Quirino State University, Quirino, Philippines
*Corresponding author: romiro.bautista@qsu.edu.ph

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Abstract The promotion of learners' mastery on concepts and carry out procedures is one of the mainstreams of authentic learning in the pace of student-centered instruction. The ability of the learner to constantly learn and improve in every discipline and intertwined discipline is associated with its primordial learning of concepts and procedures. This study aims to further improve the procedural understanding of students along the selected concepts of forces and motion using the Project MC^2 (Modelling, Comprehension, and Collaboration). Moreover, it determines the significant difference between the control and experimental groups with regard to their conceptual and procedural understanding. The data gathered revealed that; (1) the experimental group earned higher mean gain score. This posted a great margin for consideration; (2) there is a significant difference between the procedural fluency of the students which is hypothesized to be affected by the Intervention Program (Program MC^2). This is construed with the eta value of .701 accounting to at least 70.10% of the measured effects of the intervention program; and (3) the improvement of students' procedural fluency includes devising appropriate diagrams and solutions in answering problem solving and applying it to real life activities. This implies that the implementation of the Project MC^2 significantly enhanced the procedural fluency of the respondents on the concepts of forces and motion.

Keywords: *Project MC^2, conceptual understanding, procedural fluency, action research*

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1. Introduction

Teaching Physics in a high school setting is a challenge for teachers especially with the incorporation of other core subjects and discipline. Physics is always perceived as a hard subject due to the integration of conceptual and mathematical analysis and the belief that mathematics-related subjects are hard. This belief of students often results to low performances of the students [1,2]. However, the procedural fluency of students in solving Physics problems posts a great impact in carving the desired learning outcome to be mastered [3].

Physics, being a hybrid course, employs the convergence of both conceptual understanding and procedural fluency. Conceptual understanding when it comes to learning does not only carry out rote memorization but entails the ability to determine relationship and provide authentic understanding [4]. Moreover, learners encounter concepts every day, the level of students' conceptual understanding may affect their interpretation if they are introduced to the topic where the concept was incorporated [5].

Concurrently, procedural fluency builds students' critical thinking and mathematical proficiency. It teaches the students to recognize, modify, and apply appropriate procedures and solution to practice. In addition, procedural fluency does not only coerce with rote memorization of the procedures but being able to use appropriate one in every solution [6]. Thus, students' problem solving ability underscores both understanding and efficiently communicate mathematical ideas. This fact establishes a strong link on the conceptual understanding, strategic reasoning, procedural fluency, and problem solving ability of the learners [2,7,8].

However, both science and mathematics had an erring student conception when it comes to learning as may affected by various teaching techniques and learning factors [1,5,8]. This was affected by consistency and level of student's motivation to learn due to sudden decline if they feel uncomfortable with the topic being discussed which implies to have an interactive teaching and learning environment [1,9]. These pave numerous ideas to develop a teaching strategy that will cater the students' motivation to learn and improve their over-all performance.

Aptly, both conceptual understanding and procedural fluency must go hand in hand to ensure students learning and mastery of concepts and carry-out procedure. Thus, this research intends to improve the student's procedural

fluency along the concepts of forces and motion through the implementation of Project MC^2.

1.1. Objectives of the Study

This study aims to determine the effect of Project MC^2 on improving the procedural fluency of the students along concepts of forces and motion in Physics. Specifically, it aimed to:

1. determine the mean gain score of the students on the procedural fluency in Physics;
2. evaluate significant differences on the procedural fluency along forces and motion in Physics;
3. evaluate the effect size of the treatment condition on the procedural fluency along forces and motion in Physics.

1.2. Theoretical Framework

This study was anchored with three governing theories that entails students learning: Kolb's Experiential Learning Theory, Vygotsky's Social Learning Theory, and Constructivist Theory of Learning.

Kolb Experiential Learning Theory [10]. This theory underscore that knowledge is develop through the transformation of experiences. This theory follows a four step stage learning experience: (1) Concrete Experience wherein a new experience or situation is encountered; (2) Reflective Observation of the new experience which differentiate a particular importance of any inconsistencies between experience and understanding; (3) Abstract Conceptualization where it gives rise to a new idea or it modifies an existing abstract concept that had been learned from their experiences, and lastly, (4) Active Experimentation where at this stage allows the student to apply their ideas through experimentation and modeling to see the result of their ideas.

This four-stage learning pattern helps to stir up the creativity and critical thinking of the learners to learn and decide for themselves all through-out the learning process.

Vygotsky's Social Learning Theory [11]. The theory believes in the context that learning always occur and cannot be separated from the social environment. This theory explains how we learn from each other through our interactions and communications with others. Looking through the lens of this theory, it create an environment guided and directed interactions to take place.

Constructivist Theory of Learning [12]. The mainstream of this theory posit that individuals own knowledge was constructed through their own experiences. The more engagement the learners have the more knowledge they generate through this activities.

2. Methodology

2.1. Design

The Quasi-Experimental research design was used in this study. This research design identifies control groups and experimental groups in terms of their characteristics before the application of the intervention. The control group portraits the desired outcome if the intervention program was not implemented. On the other hand, the experimental group reveals the outcome if the intervention program was being implemented. This design fits to test casual hypotheses.

2.2. The Intervention Program – Project MC^2

The Project MC^2 stands for Modelling, Comprehension and Collaboration.

Modelling. Modelling includes the making of the real life model or realia of the concepts being incorporated in the lesson. This stirred up the creativity and understanding of the students. The model allows students to perform several activities on key concepts and requires them to scientifically explain such concepts using mathematical processes. The respondents made water rocket launcher, a device used to observe the application of projectile motion in rockets and other objects.

Comprehension. Comprehension incorporates the individual problem solving activity of the students. After the conduct the activity, a series of problem solving activities supplemented the learning of the students regarding the said concept. This showcased the procedural fluency of the students regarding the topic or lesson being discussed.

Collaboration. Collaboration allows the students to work in pairs or in group. After performing and answering the activity and problem set, students were allowed to discuss in pairs or in groups to further widen and strengthen their knowledge regarding the topics. A simple group presentation or reporting following a series of guide questions was done.

Project MC^2 may be eclectically reconducted in a class in the following manner: First, the teacher groups the class into small groups of learning. Study leaders will be assigned by the teacher based on their readiness on the topic. Study leaders will be tutored beforehand by the teacher for them to master the concepts. Study leaders will be guided and tutored on the ideation of the concept. Moreover, the study leaders will form a study group facilitated by the teacher along techniques on how they can transfer the concept to their classmates in a manner that is as comprehensible as the teacher's way of delivering it to them.

Modelling comes with visualization using real objects through simulations using realias since the subject is on science. The teacher models the simulation with deep ideation of the concept. Second, the teacher needs to develop comprehensible input along the development of procedural knowledge and fluency towards the concept through simulations enriched with drills and problem solving skills. Third, the teacher assigns the trained study leaders to functional groups like diads, triads, among others under the spirit of collaboration. In this part, all students per learning group will repeat the process of modelling in building comprehension and collaboration. Study leaders will move from one group to another until such time that they attended all the learning groups.

2.3. Locale and Respondents of the Study

This study was conducted at Quirino General High School located at Zamora, Cabarroguis, Quirino, Philippines. A

total of 78 Grade 9 students who have Physics subjects in the fourth quarter were chosen as the respondents of the study.

The respondents were divided into two groups. One group was labelled experimental while the other served as the control group. No intervention program was applied in the control group. Furthermore, the Project MC^2 was implemented in the experimental group during the last quarter of S.Y. 2019-2020.

2.4. Data Gathering Procedure

A Pre-test was administered to both groups of respondents before the conduct of the project. After the data were gathered, the experimental group experienced the integration of Project MC^2 in their daily learning routine. The control group received the normal set-up, the usual classroom demonstration, experimentation, and problem solving procedure. After the project implementation, a follow up post-test was administered to both groups of respondents. Data were gathered and recorded for further analysis.

2.5. Data Instrument/Procedure

The instrument used in this study is composed of five problem solving items to measure the procedural fluency of the learners. The test questionnaire was checked and edited by the cooperating teacher of the principal author and other experts to ensure validity in accordance with the implemented curriculum. The problem set was based and aligned with what is reflected in the curriculum manual. The data were analyzed using using the SPSS application for the mean, t-test, and Eta. Eta was used to determine the effect of Project MC^2 on the procedural fluency of the students.

3. Results and Discussion

Table 1. Mean Gain Score on the Procedural Fluency between the Control and Experimental Group

Class	Mean Gain Score
Control Group	2.11
Experimental Group	9.42

As gleaned on the table, the mean gain score of the experimental group is much higher, the 7.31 is a great margin. It can be inferred that students develop procedural fluency much better using the provisions of Project MC^2. Further, it is observed that students answer given word problems and devised their own model of the real-life application of forces and motion. This entails the development of their critical and logical thinking to continuously improve, apply, and explain the concepts within it [6,7].

Table 2. t-test on the Significant Difference on the Procedural Fluency of the Respondents

Variable	t-value	p-value	Decision
Procedural Fluency	-8.402	.000*	Reject Ho

*Significant at .05 level of significance.

Table 2 shows the t-test results posting the significant difference on the procedural fluency of the respondents. It can be gleaned that the p-value is less than .001 at .05 level of significance. These results led to the rejection of the null hypothesis. This means that there is a significant difference on the procedural fluency between the control and experimental group as stipulated in Table 1. The rejection of the null hypothesis on the procedural fluency of the respondents proved that using modelling, collaborative and comprehension approaches of Project MC^2 helped in nurturing the cognitive and affective domains of learners [3,13]. It can be said, therefore, that the provisions of Project MC^2 enabled the students to develop and establish learning strategies and improved their mathematical ability in problem solving [1,2,7,9].

Table 3. Eta Value on the Procedural Fluency of the Respondents

Variable	Eta value
Procedural Fluency	.701

Presented in Table 3 is the computed Eta value or the degree of effect of Project MC^2. The results show that the Eta value for the procedural fluency is set at .701 or equivalent to 70.10% which signifies a strong association. Thus, the procedural fluency of the students has improved with the implementation of the intervention program.

The results presented in Table 1, Table 2, and Table 3 imply the success and effectiveness of the implementation of Project MC^2. The improvement of students' procedural fluency was affected by their undertakings in collaborative learning, modelling, and comprehension in understanding problems and concepts related to forces and motions in Physics. In addition, the collaborative learning contributed on the improvement of learners in their procedural fluency as supported by the results as frame of reference [7,8] that collaborative learning is effective as students perform well in groups than those who did it alone.

Furthermore, it is also evident in the findings of reference [14] that the procedural fluency of students in Physics underscores the use of modelling to be associated in increasing the depth of understanding among them. Moreover, engaging students to problem solving and allowing them to carry-out effective solutions through modelling enhances their cognitive and mathematical ability. The studies of references [5,8,14] suggested that the use of models and work examples develops students' conceptual understanding through valid reasoning. This also improves their procedural fluency by integrating flexibility, accuracy, efficiency and appropriate use of strategy as characteristics of fluency as averred by reference [15].

Furthermore, students develop appropriate understanding and they apply concepts using cognizable models. These results were evidently supported by the findings of reference [6] when they concluded that students develop new scientific method of reasoning in dealing problem solving as a result of the new approach on learning. The combination of the three parts yield better results as shown on the tables. This further implies the effectiveness of the intervention in improving the procedural fluency of the students along the concepts of forces and motion in Physics.

4. Conclusion

Based on the results of the study, the following conclusions were drawn:

1. The experimental group earned higher mean gain score. This posted a great margin for consideration;
2. There is a significant difference between the procedural fluency of the students which is hypothesized to be affected by the Intervention Program (Program MC^2). This is construed with the eta value of .701 accounting to at least 70.10% of the measured effects of the intervention program;
3. The improvement of students' procedural fluency includes devising appropriate diagrams and solutions in answering problem solving and applying it to real life activities.

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