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Understanding the Newton's Motion Concept Through Qualitative and Quantitative Teaching

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Abstract

This research aims to analyze the influence of qualitative teaching and quantitative pursuit on understanding the concept of motion Newton Student of Science Education Study Program of FMIPA UNM. The main objectives of this study were to obtain information: 1) the characteristics of pretest and post-test results of understanding of Newton's motion concepts of students following qualitative teaching, 2) characteristics of pretest and post-test results of understanding of Newton's motion concepts of students following quantitative teaching, 3) student activities, and 4) a significant difference understanding of Newton's motion concepts of students who follow qualitative teaching and who follow quantitative teaching. The research method used is mixed. The embedded experimental model, the population of 100 student's odd semester of 2019/2020 divided into group A of 50 students and group B of as many as 50 students. The techniques used for data collection were interviews and tests, and the data were analyzed qualitatively and quantitatively. The results of the study were found in group A: 1) initial understanding of Newton's concept based on Aristotelian's theory of 30 students (60 percent), Impetus 15 students (30 percent), and Newton's five students (10 percent). The post-test result of understanding Newton's concept of motion is based on the theory of Aristotle for one student (2 percent), impetus's theory for four students (8 percent), and Newton's theory for 45 students (90 percent). In group B: 2) early understanding of Newton's motion concept based on Aristotelian theory for 35 students (70 percent), Impetus theory for ten students (20 percent), and Newton's theory for five students (10 percent). The post-test result of understanding Newton's concept of motion based on the theory of Aristotle for five students (10 percent), Impetus theory for 35 students (70 percent), and Newton's theory for ten students (20 percent); 3) student activity in following learning included in the high category, and 4) There is a significant difference understanding of Newton motion concept of students who follow qualitative teaching and who follow quantitative teaching. The study found that strict mathematical formulations do not foster the ability to comprehend the physical concept qualitatively. Students are generally only interested in solving physics problems that are manipulating numbers and equations. They are not passionate about the qualitative aspects of mathematical formulations.

Keywords: Newton's motion concept, qualitative teaching, quantitative teaching

INTRODUCTION

Effective teaching in a lecture is manifested by the mastery of the material as well as the teaching skills of the lecturers. Of course, the material taught will significantly color how the material is delivered. This is often less realized by the lecturers, resulting in less exciting lectures, especially in the eyes of a quality that is considered complex, such as physics. As a result, students lack an understanding of the concepts of physics.

Concepts in physics are generally formulated from the general impression of the observed natural phenomena of everyday life. Such a common impression is usually firmly embedded, so it is challenging to be influenced or change. Unfortunately, such a general impression or intuition is not always consistent with the facts of physics (Dittrich 2014). In the case of motion, for example, if a student holds a ball while walking and then releases the ball, there will be three possible trajectories the ball takes when it falls to the ground. Our general impression will be that the ball is falling straight down or even moving backward. Physically, the forward parabolic ball path due to the combination of student translational motion with the motion of the ball accelerated downward due to gravitational pull. In today's physics, the concept of motion can be grouped into three major sections: Aristotelian's theory, Impetus theory, and Newton's theory (Aristotle 1984; Quintaneiro 2015; Olesiak 2015). The first two theories, Aristotelian's and impetus's, were abandoned by students. Today's accepted theory of motion is based on Newton's theory, commonly called Newtonian (Crowell 2008; Said, Arsyad & Tawil 2021). If the student university student submitted a case as above or a similar set of cases, the answers given could be grouped according to the three concepts of motion above. This grouping is not influenced by whether the student has obtained a mechanics course or not. The results of McCloskey (1983) and Tawil (2016) suggest that the erroneous conception of motion is systematic and based on intuition, contrary to Newtonian mechanics (Chang, Bell & Jones 2014; Poutot & Blandin 2015; Negoro & Karina 2019). He also found that even trained students had a false concept of motion.

Newton's law of motion is one of the basic concepts that students must master as prospective physics teachers. The study of motion in physics has been carried out since the Greeks' time, which Newton described further and in more detail. Everything related to a motion must involve Newton's laws of motion (Erfan & Ratu 2018; Syamsidar, Khaeruddin & Helmi 2021). This is the basis for conducting research on the concept of Newton's motion through quantitative and qualitative teaching so that students better understand the basic concepts of Newton's laws of motion.

The fact shows that quantitative teaching of science tends toward the ability of mathematical manipulation, leaving behind the ultimate goal of conceptual understanding (Tawil 2017). Understanding the genuine concept of motion is very important for students to support their learning achievements and their application in everyday life. For students in science education programs, this becomes very important again because, as prospective teachers, they are expected to transfer the correct concept to the students when they serve in school. On the other hand, there are limits to qualitative reasoning: 1) in several situations, it remains indeterminate since it is not possible to predict the outcome; 2) it does not discern the relationships between several variables because it remains limited to the comparison of changes between pairs of variables; 3) The units of the variables are not taken into account because these units are determined by the measurement process that refers to the existence of an operational definition of the concept. And on the other hand, quantitative reasoning makes it possible to specify the functional relations between variables relevant to a phenomenon. In addition, this reasoning makes it possible to consider the interactions between several variables. Finally, the formulation of a rule in the form of an equation makes it possible to explain the properties of a phenomenon in the form of a system of relations of great generality (Trudel, Metioui, & Arbez 2020; Zhou, Xu, & Martinovic 2017; Halim et al. 2020).

Based on the above description, the problem in this research is 1) What are the characteristics of the pretest and post-test results of understanding the Newton motion concept of students following the qualitative teaching? 2) How are the characteristics of the pretest and post-test results of the understanding of Newton's motion concept following quantitative teaching? and 3) Are there significant differences in understanding Newton's motion concepts of students who follow qualitative and quantitative teaching?

METHODS

Population in this study all students of science education program semester odd year 2019/2020 of FMIPA UNM which program subjects interaction between physical factor as much as 100 students'. The population is divided into two groups: group A students are 50 students and group B students are 50 students.

The research method used is mixed methods research design Embedded Experimental Model (Frels et al. 2014), as shown in FIGURE 1.

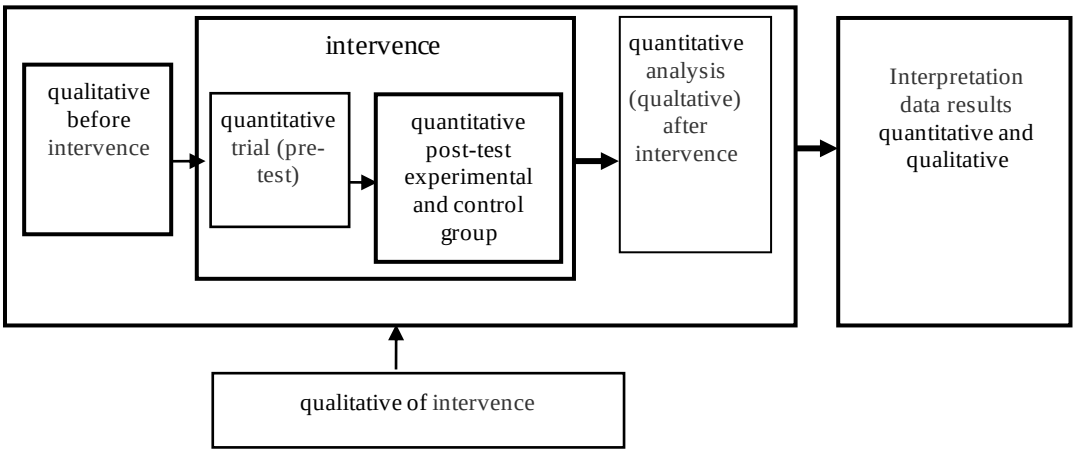

FIGURE 1. Embedded experimental model

The embedded experimental model (FIGURE 1) may be the most commonly used embedded design variant (Tawil 2017). This model is defined by having qualitative data embedded within an experimental design (such as an actual or quasi-experimental). The quantitative, experimental methodology establishes the priority of this model. This design can either be used as a two-phase, qualitative data can come before the intervention, to shape the intervention, to develop an instrument, select participants after the intervention (experimental and control group), to explain the results of the intervention or to follow up on the experiences of participants with certain types of outcomes. For the embedded experimental model: 1) the researchers must decide at what point in the experimental study to collect the qualitative data (before, during, or after the intervention). This decision should be made based on the intent of including the qualitative data (e.g., to shape the intervention, to explain the process of participants during treatment, or to follow up on results of the experimental trial), 2) for before-intervention approaches, the researcher needs to decide which qualitative results will be used in the quantitative phase and to consider how to plan the quantitative phase before the qualitative phase has been conducted. Again, the qualitative data collection should be carefully designed to match the intent for including qualitative data, such as to develop an instrument or shape the intervention, 3) for during-intervention approaches, the qualitative data collection may introduce potential treatment bias that affects the outcomes of the experimental, 4) for after-intervention approaches, decisions must be made about which aspect of the trial will be further explored. The researcher must specify the criteria used to select the participants for the follow-up data collection.

Stage Before Intervention

Analyze the course syllabus of interaction between physical factors

1. Course syllabus interaction between physical factors. Analysis of the syllabus of recovery interaction between physical factors in science education program Faculty of Mathematics and Natural Sciences Makassar State University. This syllabus has encompassed two stages: the material analysis of recovery and task analysis.
   The analysis of the recovery materials is intended to select and establish, detail, and systematically compile relevant lecture materials to be taught based on competency standards, essential competencies, and indicators to be achieved in the recovery of interaction between physics factors.

The task analysis aims to identify the key indicators needed in the interaction between physics factors and analyze them in the learning device's frame of motion concept.

2. Analyze student needs. Analysis of student needs that support qualitative and quantitative teaching. Information at this stage is obtained through analysis of the results of a preliminary survey on the implementation of teaching interaction between physical factors in the science education program Faculty of Mathematics and Natural Sciences at Makassar State University.
3. Analyze resources and facilities. Information at this stage is obtained through analysis of the initial survey results on the facilities/infrastructure available to support the implementation of the interaction between physical factor lectures and learning media. The researcher conducted an applied teaching assessment analyzing learning resources and facilities.

Stage of Competence Formulation

The formulation of competence is intended to convert the competence of the material analysis and task analysis into sub-competencies (fundamental competencies), indicators to be achieved, including the indicators of concept comprehension.

Development Stage of subject matter

Activities undertaken at this stage are to develop 1) qualitative and quantitative teaching (syntax, social systems, support systems, and instructional and nurturant effects) taking into account the characteristics of conceptual understanding; 2) learning tools, consisting of lesson plans, student activity sheets; and 3) research instruments (Newton's concept of motion comprehension test, open-ended interviews manual) and qualitative analysis (teaching characteristics applied) using observation sheets.

Research Instrument Development Stage

At this stage, two research instruments were developed: a concept comprehension test (i.e., Aristotelian theory, Impetus theory, and Newtonian theory), open-ended sheet interviews, and an observation sheet. The development of this instrument is based on the indicators of Newton's understanding of concepts. Furthermore, the concept of understanding tests in validation by a mechanical expert to know the level of validity and reliability.

The Pretest Stages and Interviews are open-ended

At this stage, pretest and open-ended student interviews are performed in group A, as well as in group B. The test used in the pretest is the comprehension test of Newton's motion concept. Meanwhile, the implementation of open-ended interviews is equipped with a tape recorder. The interview was conducted in 10 stages, with each stage, ten students attending interviewed.

Implementation Phase

At this stage activities are carried out:

1. Implement qualitative learning in group A with phases: 1) Presentation of Data and Identification of Concept, 2) Testing Attainment of the Concept and 3) Analysis of Thinking Strategies. In group B, quantitative study is applied with phases: 1) conveying learning objectives and preparing students, 2) demonstrating knowledge and skills, 3) guiding training, 4) checking to understand and providing feedback, and 5) providing practice and application of concepts. Implement post-test and student interviews both in group A and in group B. The test used in the post-test is a test of understanding the concept of Newton's motion. Meanwhile, the implementation of interviews open-ended interviews is equipped with a tape recorder.
2. Collect and analyze qualitative and quantitative data (Chen 2006; Johnson 2011).

Stage of Interpretation

At this phase, the quantitative and qualitative interpretation data are drawn to draw conclusions and report the study results. The subject of this study is all students in the academic year 2019/2020 in the science education program at one of the State University of Makassar, during which the experiment they took lectures on the interaction between physics factors. The instruments in this study were interviews, an open-ended sheet, and an understanding of the concept of motion Newton test.

Data analysis is done by referring to the research problem. Based on the research problem, quantitative and qualitative data analysis is done in two ways. To answer the test results of understanding Newton's concept of motion, it used descriptive statistical analysis and inferential analysis using a two-sided "t" test. In addition, to clarify the interpretation of the analysis results, data acquisition is also described in diagrams. For the research implementation, the dominant syllabus analysis of the interaction between physical factors and student activity is qualitative. It has been implied in all activities undertaken at each stage of applying qualitative and quantitative teaching. This analysis is performed on all components of the teaching application performed by Bruce Joyce, Marsha Weil, and Showers (syntax, social systems, reaction principles, support systems, and instructional and nurturant effects). While the quantitative data of the program will be analyzed using inferential statistics.

RESULTS AND DISCUSSION

Qualitative Before Intervention

Characteristics of Interaction Physics Interaction Lecture Materials

The course syllabus on the interaction between physics factors consists of the topic of kinematics and dynamics. Material kinematics consists of several topics: 1) motion with constant velocity and 2) motion with changing velocity. While the material dynamics, namely: 1) Newton's first law, 2) Newton's second law, and 3) Newton's third law. Fundamental competencies, students can understand concepts and analyze: 1) motion, position, distance, and displacement, 2) speed and acceleration, 3) straight motion, 4) vertical motion, parabolic motion, 5) circular motion, 6) Newton's first law, 7) Newton's second law, and 8) Newton's third law. The indicators, namely, the students can find the different concepts of motion: Aristotelian theory, Impetus theory, and Newton. This study only focused on the topic of kinematics because, on this topic, many students cannot understand the concept of motion (Tawil 2015).

Development of Research Instruments

Based on the indicators of the achievement of teaching objectives, then developed a test of understanding the concept of Newton motion accompanied by an interview sheet and the observation sheet. The number of question items that meet the validity of five items from ten items of matter with a reliability of 0.98. At the same time, the open-ended interview sheet item is adjusted with the number of items a valid question. Observation sheets are adapted to the qualitative and quantitative teaching syntax. The observation sheet comes with observer filling instructions.

Items about understanding Newton's concept of motion are as follows:

Problem-1.

The projectile path trajectory horizontally can be seen in FIGURE 2.

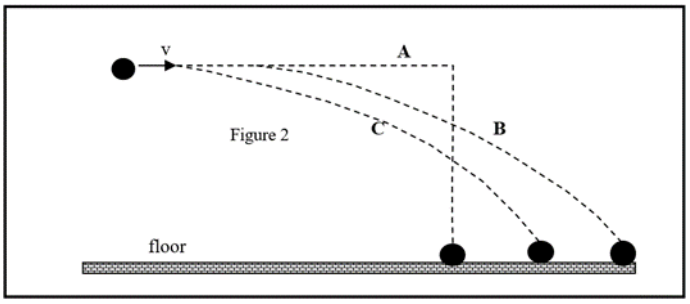

FIGURE 2. Projectile path trajectory horizontally

- Students are asked to check the path of a projectile fired horizontally form of a tower. The path formed by the projectile is given as in FIGURE 2. Which path follows a projectile?
- Interview: Clarify the theory underlying your answer choice?

Problem-2.
FIGURE 3, shows the trajectory of a circular object moving in a pipe, as shown below

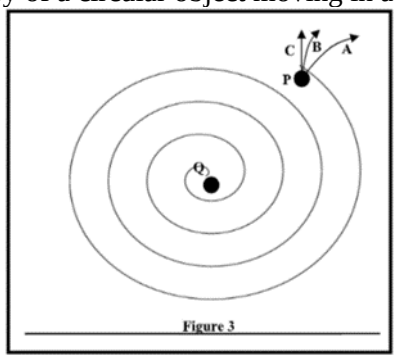

FIGURE 3. The trajectory of a circular object moving in a pipe

- Students are required to predict the trajectory of moving objects circular inside a pipe, but after the object leaves the other end pipe, as FIGURE 3. Which path is following objects?
- Interview: Clarify the theory underlying your answer choice?

Problem-3
FIGURE 4, shows an empty circular pipe fired from inside the pipe from point A to point

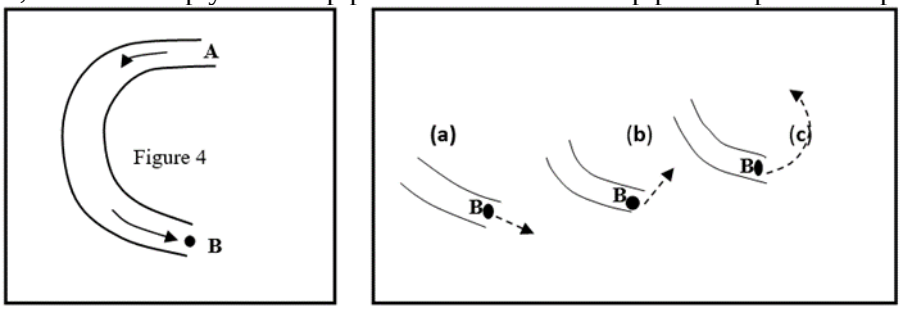

FIGURE 4. The empty circular pipe fired from inside the pipe from point A to point B

- FIGURE 4, shows an empty round pipe on a horizontal table without friction. You look from above. A ball is fired into the pipe at point A, and the ball leaves the pipe at point B at a high rate. Which track will the ball follow on the table after leaving the pipe?.
- Interview: Clarify the theory underlying your answer choice?

Problem-4
FIGURE 5, shows the movement of the ball X sliding into the planes AB and BC as shown below

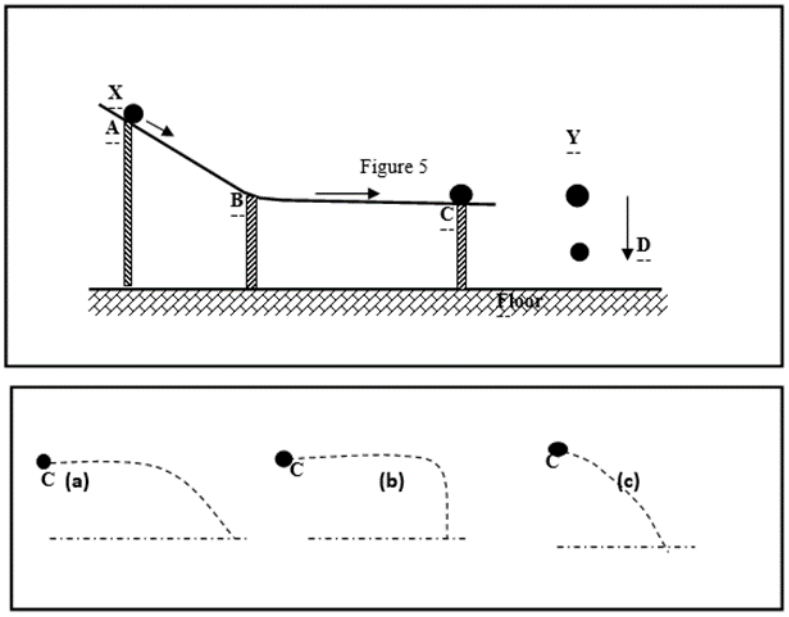

FIGURE 5. The movement of the ball X sliding into the planes AB and BC

- FIGURE 5, shows a moving X ball. The ball slips down on the AB field, then on the BC track, which is horizontal and without friction. At point C, the ball leaves the track. Ignore air resistance. Which trajectory is following after the ball off from point C?.
- Interview: Clarify the theory underlying your answer choice?

Problem-5
FIGURE 6, The moon revolves around the earth in a circle

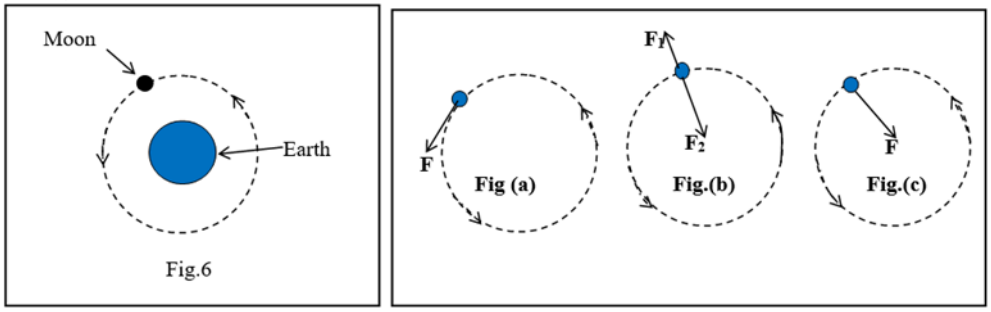

FIGURE 6. The moon revolves around the earth

- The moon circles the earth continuously in its circular motion in FIGURE 6. Choose one of three answers that fulfill the motion of the month.
- Interview: Clarify the theory underlying your answer choice?

Characteristics of Qualitative and Quantitative Teaching

Qualitative and quantitative teaching equipped with learning tools and instruments are based on the development of instruction according to Bruce Joyce & Showers 1992 and James W Drisko 2016, 1) Syntax: a) orientation, b) student training, c) consolidation, d) evaluation, 2) Social system: cooperation between students and students and lecturers seriously carry out activities in teaching, 3) Management principles: in this teaching, the lecturer acts as facilitator or facilitator. In the overall process of recovery, teachers are tasked with and responsible for maintaining an atmosphere of learning by showing a supportive attitude, 4) support systems: media means to support teaching implementation (computers and teaching devices); 5) instructional and nurturant effects: instructional impacts: understanding the concept of motion, and the nurturant effects are

the ability to develop creativity. Apply qualitative and quantitative teaching by following the teaching syntaxes that have been made. Implementing this teaching is expected to improve understanding of Newton students' motion concepts.

Respondent Characteristics

The cognitive abilities of respondents who follow qualitative and quantitative teaching are assumed to be homogeneous. The average cumulative grade point average of respondents was 3.20 in the odd semester of 2019/2020, and their social skills were excellent; it was shown to communicate, cooperate in problem-solving, be responsible, and be disciplined following the recovery. The average percentage of their attendance fulfilled the policy and regulation academic of UNM in chapter 5, related lectures, study period, and academic leave article 21 paragraph (4) stating that every student can take the final exam of a semester after taking 80% of lecture.

The average high-level thinking skills, especially the skills of the science process and the creative thinking skills of the students who follow the lectures, are high (Tawil 2013a; Tawil 2013b).

Quantitative Pre-measure Results

Group A Pretest results

TABLE 1. Aristotelian Theory Results

Problem	Answer	Number of respondents	Percentage
1.	A	10	20
2.	A	5	10
3.	A	5	10
4.	B	5	10
5.	B	5	10
Amount		30	60

Interview Results

After the respondents completed the question pretest and then interviewed, TABLE 1 found that 30 students, or 60 percent, still used the theory of Aristoteles.

1. Problem-1, ten students, or twenty percent of students, choose to answer A on the ground that the rifle gives a large thrust force to the bullet that overcomes its gravity. As a result, the projectile is straighter. But the force of the thrust is slowly shrinking, and its gravity pulls the bullet down to the ground in a straight line. In such an opinion, the meaning of the natural projectile motion that is always falling to earth to its proper place.
2. Problem-2, five students, or ten percent of students, choose to answer A because this motion is like project motion. They argue that a force keeps the object moving circular when it escapes from the mouth of the pipe at point P and follows A slowly discharged and causing a stationary object.
3. Problem-3, five students, or ten percent of students, choose to answer A because a force keeps the object moving away, leaving the path from point B slowly discharged and causing the stationary object.
4. Problem-4, five students, or ten percent of students, choose to answer B because there is a significant thrust to the object gliding, and the force overcomes the gravity. Consequently, the object moves straight. However, the thrust is slowly shrinking, and its gravity pulls it down to the ground in a straight line.
5. Problem-5, five students, or ten percent of students, choose to answer B because the Centripetal force and the large centrifugal force are each equal and keep the moon in a circular motion. As a result of such a concept, the resultant force is zero. Then the moon will move straight uniformly (straight with fixed velocity).

TABLE 2. Impetus Theory Results

Problem	Answer	Number of respondents	Percentage
1.	B	3	6
2.	B	2	4
3.	A	3	6
4.	A	2	4
5.	B	5	10
Amount		15	30

Interview Results

After the respondents completed the question pretest and then interviewed, TABLE 2 found that 15 students, or 30 percent, still use impetus theory.

1. Problem-1, three students, or six percent of students, choose to answer B because the project will move straight for a moment and then form a parabola due to the earth's gravity.
2. Problem-2, two or four percent of students choose to answer B on the grounds that after loose at point P, the object loses a circular force, so it moves straight. But because the object tends to maintain its motion, the object is in a circular motion. This opinion seems to be based on Newton's first law but with a misconception.
3. Problem-3, three students, or six percent of students, choose to answer A because there is a force that pushes things to move straight, leaving the path from point B, which is slowly exhausted and causes a stationary object.
4. Problem-4, two students, or four percent of students, choose to answer A on the grounds that there is a significant thrust to the object moving straight for a moment and then forming a parabola due to the earth's gravity.
5. Problem-5, five students, or ten percent of students, choose to answer B because there is a force towards the motion so that the moon moves in a circle.

TABLE 3. Newton's Theory Results

Problem	Answer	Number of respondents	Percentage
1.	C	1	2
2.	C	1	2
3.	B	1	2
4.	C	1	2
5.	D	1	2
Amount		5	10

Interview Results

After the respondents completed the question pretest and then interviewed, TABLE 3 found that five students, or ten percent, used Newton's theory.

1. Problem-1, only one student or two percent of students chose C. They argue that project motion is affected by two velocity vectors, Vx and Vy, the resultant V $= \sqrt{v_x^2 + v_y^2 + 2v_x v_y cos\alpha}$, so the path taken by the projectile is path C.
2. Problem-2, only one or two percent of students choose to answer C because the object's velocity is always tangential and perpendicular to the circle's radius.
3. Problem-3, only one student or w percent of students choose to answer B because forces are acting on the object, causing changes in the velocity direction and resulting in acceleration. The acceleration is always directed to the circle's center, while the velocity is like the offensive path or the tangential direction.
4. Problem-4, only one student or two percent of students choose to answer C because project motion is influenced by two velocity vectors Vx and Vy, the resultant is $V = \sqrt{v_x^2 + v_y^2 + 2v_x v_y cos\alpha}$, so the path which is pursued by a parabolic-shaped projectile.

5. Problem-5, only one or two percent of students choose to answer D because there is only a perpendicular Centripetal force in the direction of speed so that this force only deflects the moon and does not accelerate or slow down its motion rate.

Group B Pretest results

TABLE 4. Aristotelian Theory Results

Problem	Answer	Number of respondents	Percentage
1.	A	5	10
2.	A	5	10
3.	A	10	20
4.	B	5	10
5.	B	10	20
Amount		35	70

Interview Results

After the respondents solved the pretest problem, then interviewed, TABLE 4 found that there are 35 students, or 70 percent, who still use the theory of Aristoteles.

1. Problem-1, five students, or ten percent of students, choose to answer A because the shotgun gives a large thrust force to the bullet that overcomes its gravity. As a result, the projectile is straighter, but the thrust is slowly shrinking, and its gravity pulls the bullet down to the ground in a straight line.
2. Problem-2, there are five students, or ten percent of students who choose to answer A, who argue that there is a force that keeps the object moving circular when it escapes from the mouth of the pipe at point P and follows the A path slowly discharged and finally the stationary object.
3. Problem-3, ten students, or twenty percent of students choose to answer A because a force keeps the object moving away, leaving the path from point B slowly discharged and finally the stationary object.
4. Problem-4, five students, or ten percent of students, choose to answer B because there is a significant thrust to the moving object, and the force overcomes the gravity. Consequently, the object moves straight. However, the thrust is slowly shrinking, and its gravity pulls it down to the ground in a straight line.
5. Problem-5, ten students, or twenty percent of students, choose to answer B because the Centripetal force and the enormous centrifugal force are each the same and keep the moon moving circularly.

TABLE 5. Impetus Theory Results

Problem	Answer	Number of respondents	Percentage
1.	B	2	4
2.	B	2	4
3.	A	2	4
4.	A	2	4
5.	B	2	4
Amount		10	20

Interview Results

After the respondents solved the pretest problem and were interviewed, TABLE 5 found that ten students, or 20 percent, still use impetus theory.

1. Problem-1, three students, or six percent of students, choose to answer B because the project will move straight for a moment and then form a parabola due to the earth's gravity.
2. Problem-2, two or four percent of students choose to answer B on the grounds that after loose at point P, the object loses a circular force, so it moves straight. But, because the object tends to maintain its motion, the object is in a circular motion. This opinion seems to be based on Newton's first law but with a misconception.
3. Problem-3, three students, or six percent of students, choose to answer A because there is a force that pushes things to move straight, leaving the path from point B, which is slowly exhausted and causes a stationary object.

4. Problem-4, two or four percent of students choose to answer A on the grounds that there is a significant thrust to the object moving straight for a moment and then forming a parabola due to the earth's gravity.
5. Problem-5, five students, or ten percent of students, choose to answer B because there is a force towards the motion so that the moon moves in a circle.

TABLE 6. Newton's Theory Results

Problem	Answer	Number of respondents	Percentage
1.	C	1	2
2.	C	1	2
3.	B	1	2
4.	C	1	2
5.	D	1	2
Amount		5	10

Interview Results

After the respondent completed the pretest problem and was interviewed, TABLE 6 found that five students, or ten percent, used Newton's theory.

1. Problem-1, only one student or two percent of students chose C. They argue that project motion is affected by two velocity vectors, Vx and Vy, the resultant $V = \sqrt{v_x^2 + v_y^2 + 2v_x v_y cos\alpha}$, so the path taken by the projectile is path C.
2. Problem-2, only one or two percent of students choose to answer C on the grounds that the velocity of the object is always tangential and perpendicular to the circle's radius.
3. Problem-3, only one or two percent of students choose to answer B because there are forces acting on the object, causing changes in the direction of velocity and resulting in acceleration. The acceleration is always directed to the circle's center, while the velocity is like the offensive path or the tangential direction.
4. Problem-4, only one or two percent of students choose to answer C because project motion is influenced by two velocity vectors Vx and Vy, the resultant is V, so a parabolic-shaped projectile pursues the path.
5. Problem-5, only one or two percent of students choose to answer D because there is only a perpendicular Centripetal force in the direction of speed so that this force only deflects the moon and does not accelerate or slow down its motion rate.

Furthermore, resume analysis of understanding the concept of motion before the intervention as in TABLE 7.

TABLE 7. Resume Understanding Motion Concepts

Group	Percentage of Understanding Movement Concept			Amount
	Aristotelean	Impetus	Newton's	
A	60	30	10	100
B	70	20	10	100

Qualitative During Intervention

Observation Result of Lecturer Activity

The implementation of the Semester Course Plan (SCP) during qualitative and quantitative teaching activities is observed by three observers. Observations made by the observer are written in the observation sheet of the implementation of SCP. The observation results indicate that the level of implementation of the SCP of each meeting consisting of the preliminary stage, the core stage of teaching, the stabilization stage, and the closing stage is excellent. Lecturers do not experience difficulties implementing teaching either in group A or group B.

Observation Result of Student Activity

The observation results indicate that the level of student activity during the teaching consists of the introduction stage, the core stage of teaching, the stabilization stage, and the closing stage.

Student activity in group A in comprehending every topic of motion material studied qualitatively the theories underlying the concepts studied. This is done both individually and in groups. Interaction between groups with other groups is very dynamic. Meanwhile, in group B, students understand every topic of motion studied by applying formulas to solve the problems studied. This is done both individually and in groups. Interaction between groups with other groups is very dynamic (Kilburn, Nind & Wiles 2014).

Quantitative Post Measure

Group A Posttest Results

TABLE 8. Aristotelian Theory Results

Problem	Answer	Number of respondents	Percentage
4.	B	1	2
Amount		1	2

Interview Results

After the respondent solved the post-test problem, then interviewed, TABLE 8 found that only one student, or 2 percent, still used Aristotelian theory.

Problem-4, only one or two percent of students choose to answer B because the reason remains the same before treatment. It is assumed the student has not been able to improve the concept that has been understood.

TABLE 9. Impetus Theory Results

Problem	Answer	Number of respondents	Percentage
1.	B	1	2
2.	B	1	2
3.	A	2	4
Amount		4	8

Interview Results

After the respondent solved the post-test problem, then interviewed, TABLE 9 found that four students, or eight percent, still use impetus theory.

1. Problem-1, only one or two percent of students chose answer B because the projectile will move straight for a moment and then form a parabola due to earth's gravity.
2. Problem-2, only one student or two percent of students choose to answer B on the ground that after loose at point P, the object loses a circular force, so it moves straight. But because the object tends to maintain its motion, the object is in a circular motion. This opinion seems to be based on Newton's first law but with a misconception.
3. Problem-3, two or four percent of students choose to answer A because there is a force that pushes things to move straight, leaving the path from point B that gradually runs out and causes a stationary object.

TABLE 10. Newton's Theory Results

Problem	Answer	Number of respondents	Percentage
1.	C	10	20
2.	C	20	40
3.	B	10	20
5.	D	5	10
Amount		45	90

Interview Results

After the respondent completed the post-test problem, then interviewed, TABLE 10 found that 45 students, or 90 percent, used Newton's theory.

1. Problem-1, there are ten students, or twenty percent of students choose C's answer. They argue that project motion is affected by two velocity vectors, Vx and Vy. The resultant $V = \sqrt{v_x^2 + v_y^2 + 2v_x v_y cos\alpha}$ path taken by the projectile is path C.
2. Problem-2, there are twenty students, or forty percent of students, who choose to answer C because the object's velocity is always tangential and perpendicular to the circle's radius.
3. Problem-3, ten students, or twenty percent of students, choose to answer B because there are forces acting on the object, causing changes in the direction of velocity and resulting in acceleration. The acceleration is always directed to the circle's center, while the velocity is like the offensive path or the tangential direction.
4. Problem-5, five or ten percent of students choose to answer D because there is only a Centripetal force that is always upright in the direction of speed so that this force only deflects the moon and does not accelerate or slow down the rate of its motion.

Group B Posttest Results

TABLE 11. Aristotelian Theory Results

Problem	Answer	Number of respondents	Percentage
1.	A	1	2
2.	A	1	2
3.	A	1	2
4.	B	1	2
5.	B	1	2
Amount		5	10

Interview Results

After the respondent completed the post-test problem, then interviewed, TABLE 11 found that there were five students, or ten percent, who still used Aristotelian theory.

1. Problem-1, one or two percent of students choose to answer A on the ground that the rifle gives a large thrust force to the bullet that overcomes the gravity. As a result, the projectile is straighter. But the thrust is slowly shrinking, and gravity pulls the bullet down to the ground in a straight line.
2. Problem-2 is one student, or two percent of students choose to answer A. They argue that a force keeps the object moving circular when it escapes from the mouth of the pipe at point P and follows the A path slowly exhausted and finally the stationary object.
3. Problem-3, one or two percent of students choose to answer A on the grounds that there is a force that keeps the object moving away, leaving the path of point B, which is slowly exhausted, and finally, the stationary object.
4. Problem-4, one or two percent of students choose to answer B because there is a large thrust to the moving object, and the force overcomes the gravity. Consequently, the object moves straight. However, the thrust is slowly shrinking, and its gravity pulls it down to the ground in a straight line.
5. Problem-5, one or two percent of students choose to answer B on the grounds that the centripetal force and the large centrifugal force are each equal and keep the moon moving circularly.

TABLE 12. Impetus Theory Results

Problem	Answer	Number of respondents	Percentage
1.	B	5	10
2.	B	5	10
3.	A	10	20
4.	A	10	20
5.	B	5	10
Amount		35	70

Interview Results

After the respondent completed the post-test problem and then interviewed, Table 12 found that 35 students or 70 percent still use impetus theory.

1. Problem-1, five or ten percent of students choose to answer B because the project will move straight for a moment then form a parabola due to earth's gravity.
2. Problem-2, five or ten percent of students choose to answer B because after loose at point P, the object loses a circular force, so it moves straight. But because the object tends to maintain its motion, it is in a circular motion. This opinion seems to be based on Newton's first law but with a misconception.
3. Problem-3, ten or twenty percent of students choose to answer A because a force pushes things to move straight, leaving the path from point B, which gradually runs out and causes a stationary object.
4. Problem-4, there are ten students or twenty percent of students choose to answer A because the existence of a large thrust force to the object moves straight a few moments then form a parabola due to earth's gravity.
5. Problem-5, five or ten percent of students choose to answer B because there is a force towards the motion so that the moon moves in a circle.

TABLE 13. Newton's Theory Results

Problem	Answer	Number of respondents	Percentage
1.	C	2	4
2.	C	3	6
3.	B	2	4
4.	C	1	2
5.	D	2	4
Amount		10	20

Interview Results

After the respondent completed the post-test problem, then interviewed, TABLE 13 found that ten or twenty percent of students use Newton's theory.

1. Problem-1, there are two student or four percent of students choose to answer, they argue that project motion is affected by two velocity vectors Vx and Vy, the resultant $V = \sqrt{v_x^2 + v_y^2 + 2v_x v_y cos\alpha}$, so the path taken by the projectile is the path C.
2. Problem-2, three or six percent of students choose to answer C because the object's velocity is always tangential and perpendicular to the circle's radius.
3. Problem-3, only two or four percent of students chose answer B because there is a force acting on the object causing a change in the direction of velocity and resulting in acceleration. The acceleration is always directed to the circle's center, while the velocity velocity likes the offensive path or the tangential direction.
4. Problem-4, only one or two percent of students choose to answer C because project motion is influenced by two velocity vectors Vx and Vy, the resultant is $V = \sqrt{v_x^2 + v_y^2 + 2v_x v_y cos\alpha}$,, so a parabolic-shaped projectile pursues the path.
5. Problem-5, two or four percent of students choose to answer D because there is only a perpendicular centripetal force in the direction of speed so that this force deflects the moon and does not accelerate or slow down the rate of its motion.

Furthermore, resume analysis results understanding of the concept of motion after the intervention as in TABLE 14.

TABLE 14. Resume Understanding Motion Concepts

Group	Percentage of Motion Concept Understanding			Amount
	Aristotelean	Impetus	Newton's	
A	2	8	90	100
B	10	70	20	100

Inferential Quantitative Analysis Result

Testing Data Normality Understanding Group Motion Concept A Group

1. The test results show that $\chi^2_{hitung} = 4.78 < \chi^2_{(0.95)(3)} = 7.81$ the understanding data of group A student movement concept comes from a normal distributed population with the level of trust α = 0.05.
2. Testing Data Normality Understanding Student Movement Concept Group B
   The test results show that the students' group motion concept understanding data comes from normal distributed popups with the level of trust α = 0.05.
3. Homogeneity Testing of Variance
   The result of testing of motion concept comprehension data for student of group A and student group B shows F = 1.51<$F_{0.01(49,49)} = 1.96$. This means Ho is accepted; thus, the concept of motion understanding data has a homogeneous variance.
4. Hypothesis testing
   Test results show that $t_h = 7.01 > t_{(0.975)(98)} = 2.01$. This means Ho is rejected and thus on average the ability to understand the concept of motion based on Newton's theory differs between student group A and student group B.

Qualitative After Intervention

Interpretation Based on Qualitative and Quantitative Results

Based on the analysis of the understanding of the concept of motion of students of science education program FMIPA UNM found that the pretest result of understanding the concept of motion according to Aristotle's theory in TABLE 7 group A compared to group B only differ 10 percent, so also aspect of understanding of motion according to Impetus theory. Newton's theory of motion understanding is the same. This shows that student's understanding of the concept of motion in group A and group B is homogeneous.

The analysis results in TABLE 7 also provide information that many students use Aristotelean theory concepts and Impetus theory (90 percent) in explaining the concept of motion compared with Newton's theory (10 percent). It is assumed that the students acquire the knowledge at the time of studying physics in high school or at the time of the students attending fundamental physics in semester three. The implementation of this pretest is done in the fifth semester, it means that the ritual of understanding the concept can last 2-3 years.

The interview result found that the explanation expressed by students in both groups A and B on every aspect of Aristotelean, Impetus, and Newton's theory is generally not much different. These findings indicate that the mindset of the students is not much different in explaining any phenomenon of motion, either parabolic or circular motion. Student explanation by using Aristotelean theory to parabolic motion phenomenon and circular motion more accelerate approach (acceleration) can be obtained by enlarging the force. The weight gain of the object will make it closer to its proper place and when no force works, the object will immediately be silent. Every moving object always gets a force boost from the outside, this force will be passed on to the object. The moving object has a centripetal and centrifugal force in keeping the object moving circularly. Students in explaining the phenomenon of parabolic motion and circular motion, more explain by using impetus theory by involving the effects of gravity in pulling the object down and the impetus pushing the object so that it moves horizontally, and this motion has air resistance causing the object to move slowly and eventually impetus exhausted, so it falls naturally. Circular motion of the object gets a motion-shifting style.

Student explanation by using Newton's theory of parabolic motion phenomenon and circular motion is more to do a combination approach between scale motion and motion constant with accelerated motion toward the center of the earth, so that the path taken is always parabolic-shaped symmetrical. Movement of the object at such a constant speed along the path causes acceleration. Acceleration is always directed to the center of the circle, while vector speed always offensive trajectory or tangential direction.

Based on the post-test result after the intervention as in TABLE 16, it was found that the average score of the students' motion concept understanding that followed the qualitative teaching (group A)

was better than those who followed the quantitative teaching (group B). The test item analysis of the concept of motion shows that about 90 percent of students from group A are in the Newtonian category and only 20 percent of students from group B are in the same category.

Similarly, the category of student impetus from group A is only 8 percent lower than group B of about 70 percent. In the Aristotelean category, students in group A are only 2 percent much smaller than in group B in the same category. This finding is interesting to note that the Aristotelean concept has been largely abandoned by students who follow qualitative teaching and a belief system of sedimentary motion phenomena in impetus theory.

Students who follow quantitative pursuits can bring Newton's laws well in quantitative terms. However, many of them fail to apply it in different situations and tend to correspond with the concept of impetus in expressing phenomena such as force, momentum, gravity, and free particles. Even in understanding the projectile and circular motions, they are caught in understanding the concept of impetus.

Presentation of courses by applying qualitative and quantitative teaching is expected to give birth to the correct concept of motion and erode the system of Aristotle's understanding and impetus. This hope is not entirely fulfilled. MeCloskey et al. (1983) points out that although Newton's laws are well-known, the results show that 30 percent of college students who have received a mechanics course are still inclined to hold the theory born 3 centuries before Newton. More than 50 percent of college students who have not attended college of mechanics believe that the behavior of moving objects is contrary to Newton's laws. Similar research was conducted by Halloun and Hestenes (1985). They found that 18 percent of respondents were Aristotelean dominated, 65 percent impetus, and Newtonians dominated the remaining 17 percent. However, they also found that almost every student used a mixture of such concepts and appeared disobedient in applying the same concept to different situations. In this study Ghislandi et al. (2020), concerning a course offered during the academic year 2016/2017, we propose the qualitative analysis of students' final essays, which includes the students' opinion about teaching quality. The qualitative evaluation of teaching is then compared with the results of the standard SET survey. 48 students filled in the survey, while 47 delivered their final essay (a corpus of about 650 text pages). Our study shows that while the standard survey provides an overall valuable picture at institutional level for Quality Assurance (QA), the qualitative approach captures an accurate account of students' reactions, sensitive to the pedagogical approach adopted. This provides additional information on the students' perspectives regarding the specific features of the course. Our case study suggests that the integration of traditional SET survey with qualitative teaching evaluation approaches, at least for innovative courses based on socio-constructivist learning, might provide information, overlooked in the Italian SET survey, that is useful for Quality Enhancement (QE) of teaching. Similarly, the results of Papachristou (2014) study found that students who had studied physics about 10 percent were Aristotelean dominated, 86 percent impetus systems, and 4 percent Newtonian systems.

The findings of impetus theory in explaining circular motion, many teachers or lecturers, and students, as well as textbooks say that two forces are acting on a circular object in sequence, the centripetal and centrifugal forces in which the two forces are equal but opposite. This explanation is wrong! Suppose that is true: the two forces will abolish each other, then the resultant force (in the horizontal plane) is zero, then the object will move straight irregularly instead of circular (Newton's Law I).

Newton's force is always the effect of one thing on another. For example, the influence of the earth on objects (gravity), or the wheel on the road (compression force), or the road on the wheel (friction). So, the origin of the force always lies in other objects, but the question is where does the centrifugal force come from. We can't show objects that do centrifugal force, so centrifugal force doesn't exist. The idea of centrifugal force in circular motion stems from a misunderstanding of Newton's third law which can be formulated as follows: any object subjected to a force F will exert an interaction force F equal to F, but in the opposite direction. direction and the two styles are different. For objects moving in a circle, the central force is Fc, students automatically look for the opposite force to Fc. However, the two forces in Newton's law do not act on the same thing, but on different things. This centrifugal force can also be derived from the everyday experiences of students. For example, when students get on a car or bus that turns a corner, students feel pushed out. Students say that an external force

(centrifugal force) is acting on us. But, not so, according to Newton's first law, everything tends to move in a straight line.

The concept of a circle, it must be emphasized that the force generated acting on a circular object is a force observed by a silent observer and outside the system, not a force "perceived" by a self-circling object. If the word centripetal always creates a "centrifugal force", we can say other words like "central force". For "centripetal acceleration" we can use "central acceleration". All the questions about student parabola motion tend to explain the direction of the motion of the direction of motion even though there is only a downward force of gravity. Students use the impetus style that sold well in the days before Newton (Crowell 2008). The impetus theory says that moving objects require force in the direction of motion (Gile 2017). Objects moving at a steady pace also require a force in the direction of motion (contrary to Newton I law). The impetus idea fits better with everyday experience than Newton's law I. In our experience all things always need a force to maintain its speed. If there is no style, all things in this world will stop. Newton solved it with friction, but that was a reasonably abstract solution. Because Newton explicitly takes into account the frictional force, he also successfully paints the movements of celestial bodies with the assumption that friction can be ignored in space.

Based on the answers of students found both in the review before and after the teaching of qualitative and quantitative, it is possible to categorize the concept of motion that settles in their understanding. The large number of students who still embrace impetus theory shows that the teaching of mechanical material still needs to be studied more deeply by involving the deepening of the concept qualitatively, compared with the quantitative teaching. Although the concept of physics can generally be understood through various parameters strung together in some equations, students tend to have difficulty qualitatively translating mathematical symbols (Khiari 2011).

CONCLUSION

Quantitative analysis results found that students who follow the teaching of qualitative understanding of motion concept differ significantly from those who follow quantitative teaching. This means that qualitative teaching is one of the types of teaching that can be applied in the recovery to overcome the problem of student concept understanding. Students who follow quantitative teaching are more focused on creating problems by applying formulas, without realizing that conceptual understanding is also essential in solving various problems.

The improvement of the phenomena found in this study should be done totally and systematically. Total in terms of material and presentation of lectures harmonize the qualitative and quantitative. In the sense that students should be given specific exercises to change the perception of motion they believe. Such exercises include observation activities, simple experiments, and simulations of physical phenomena. Teaching is focused on conceptual knowledge rather than calculation because the concept must be mastered before its use in calculation (Cataloglu & Ates 2014). Thus, the mastery of basic concepts becomes the main objective of the physics curriculum, both in high school and at the University.

Based on the results of the findings, it is suggested that an effective physics learning process and can achieve maximum results should pay attention to, namely 1) in the learning process there should be a link with the knowledge that already exists in students; 2) students need to get hands-on experience through exploration, discovery, investigation and research activities; 3) apply the facts, concepts, principles and procedures learned in other situations and contexts; 4) exchange ideas, ask and answer questions, interactive communication between fellow students and between students and teachers; 5) emphasizes the ability of students to transfer the knowledge, skills and attitudes they already have in other situations and conditions.

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