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## **Development and Validation of Three-Tier Multiple Choice Test for Conceptual Understanding in Momentum and Collision**

**Frank Angelo A. Pacala**

*Faculty, College of Arts and Sciences, Samar State University, Catbalogan City, Philippines*

### **ABSTRACT**

*This study developed and validated a three-tier test for conceptual understanding in momentum and collision. Due limited literature in this area, this study will be an additional test instrument on this rarely researched topic. The research participants who validated the study were experts in physics education and educational assessment. Grade 9 students were also used since momentum and collision is discussed in the grade 9 level. The instrument underwent three phases: construction, pilot study, and validation. In developing the instrument, interview and literature review was used and Cronbach's Alpha was used to measure the internal consistency of the instrument.*

**KEYWORDS:** *assessment, momentum, collision, physics education, science communication, three-tier test*

### **INTRODUCTION**

Momentum and collision is one of the most important topics in physics. In this subject, students learn the relationship between mass and velocity, know how colliding bodies behave, and how momentum is conserve. Learning momentum and collision in the classroom will have big effect to students in the real-world set-up. It will allow them to explain and calculate the energy that causes the colliding bodies to be damaged during collision.

However, students fear physics due to the immensity of skills needed and problem-solving requirements. Therefore, many students have negative attitude towards physics. Bajah (1998) cited that negative attitude towards the subject is due to misconception while George (2000) suggested that it is because of incomplete of laboratory equipment which made teachers do chalk-talk. Moreover, according to the University of Rhode Island and Mazur (1996), students do not learn physics due to assessment strategy like memorization.

Therefore, assessment tools in physics affect how conceptual understanding in the subject is measured. Multiple choice test is a common assessment tool utilized by teachers because it is easy to administer and evaluate. However, this test poses many limitations. According to Klufa (2015), multiple choice test is prone to guessing which affects the reliability of the test instrument.

Moreover, a three-tier test can give further explanation and triangulate the response of the participant. In this way, educators can identify the misconception and conceptual understanding of the students.

Though there are many studies about the development of three-tier test in physics (Eryilmaz&Surmeli, 2002; Pesman&Eryilmaz, 2009; and Taslidere, 2016), very limited are published researches that are specific to measure the conceptual understanding in momentum

and collision. Hence, this study developed and validated one. This study adds up to the rare literature in this topic.

### **Statement of the Problem**

This study was aimed in developing and validating a three-tier test for conceptual understanding in momentum and collision. It is the intention of the research to inform physics educators about the effectiveness of the said instrument in turning misconceptions in momentum and collision into scientific understanding. Moreover, the study would like to answer the question, “what is the internal consistency of the test instrument?”

## **METHODOLOGY**

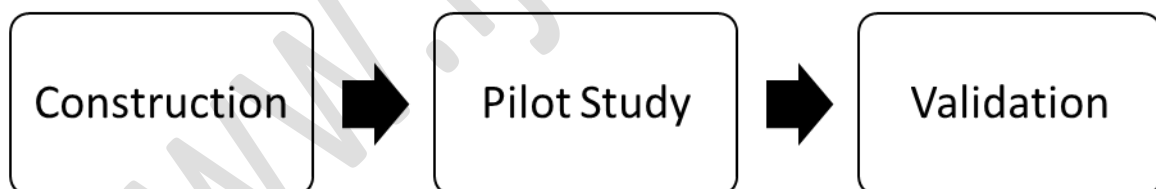
### **2.1. Sample**

The participants of this research consist of two groups: experts and students. The experts were university instructors and basic education teachers who have at least five years of teaching experience in the field of physics. They were tapped to analyze the constructed test instrument for its content and alignment to curriculum guide of K to 12.

The student-participants were 9<sup>th</sup> grade students of Eastern Visayas Regional Science High School and Pangdan National High School. They were interviewed to determine their misconception about momentum and collision. Finally, they were asked to answer the test instrument.

### **2.2. Development of the Instrument**

The three-tier test for conceptual understanding in momentum and collision underwent three phase development and validation. In phase 1 is the construction of the test, phase 2 is the pilot study, and phase 3 is the validation.



**Figure 1. Framework of the Study**

## **CONSTRUCTION**

During the phase 1 (construction of the test instrument), the Philippine Science K to 12 curriculum guide was utilized to know the scope and objectives of momentum and collision in setting up the questions. An extensive review of the related literature was conducted in order to learn additional misconceptions about momentum and collision. From these literatures, open-ended interview guides with additional probing questions were constructed. Then, 32 students (13 boys and 19 girls) were interviewed through open-ended questions to determine their misconceptions. These misconceptions were taken into account as could be distracters of the test instrument.

18 three-tier questions were constructed based on the literature review, expert advice, and misconception of the students. The first tier is the traditional multiple choice test with stem and options. The second tier is a list of possible explanation of the answer for the first tier. Lastly, the third tier will measure the attitude of the students in answering the first and second tiers whether they are sure or not sure.

### **Pilot Testing**

The pilot testing of the test instrument was held in Eastern Visayas Regional Science High School with 32 students (13 boys and 19 girls) as participants and the second pilot testing was conducted in Pangdan National High School with 46 students (33 girls and 13 boys). The participants were given 30 minutes to take the test. They were informed that the test is diagnostic in type and will not affect any part of their grades.

### **Validation**

The result of the pilot testing were gathered and analyzed for internal consistency using Cronbach's Alpha utilizing Statistical Package for Social Science (SPSS).

### **Packaging**

The three-tier test for conceptual understanding in momentum and collision was packaged according to experts' analysis, literature review, and students' misconception. The items were placed according to increasing difficulty. There are six items for linear momentum, six items for conservation of linear momentum, and six items for collision. Below are sample test items.

**Table I. Sample Test Items**

<b>Tier</b>	<b>Test Item</b>
First Tier	1. Which of the following factors determines momentum? a. mass and volume b. mass and velocity c. acceleration and gravity d. gravity and velocity
Second Tier	1.1 Please carefully select the best explanation from your answer for the question above. a. Gravity determines momentum. b. Moving objects with less velocity has momentum. c. Moving massive objects have greater momentum. d. Massive objects occupying larger space have greater momentum.
Third Tier	1.2 How sure were you answer for the questions above? a. I am sure. b. I am not sure. c. I completely guessed the item.
First Tier	2. Which of the following best describes when two objects collide each other? a. They both lose momentum at the moment of impact. b. The object with greater mass always has greater momentum.

	<p>c. The momentum before the collision is always greater than the total momentum after the collision.</p> <p>d. The sum of their momentums after the collision is equal to the sum of their momentums before the collision.</p>
Second Tier	<p>2.1 Please carefully select the best explanation from your answer for the question above.</p> <p>a. The impact will cancel the momentum of two bodies, hence momentum is lost.</p> <p>b. The velocity of objects is greater before collision and lesser than after collision.</p> <p>c. Momentum is directly proportional to mass; therefore, massive objects have greater momentum during collision.</p> <p>d. During collision, momentum from one object can be transferred to another object but momentum will stay the same.</p>
Third Tier	<p>2.2 How sure were you answer for the questions above?</p> <p>a. I am sure.</p> <p>b. I am not sure.</p> <p>c. I completely guessed the item.</p>

As seen from table1, numbers 1 and 2 are first tiers, numbers 1.1 and 2.1 are second tiers, and numbers 1.2 and 2.2 are third tiers.

This instrument will be scored according to the table below.

**Table II**  
**Scoring the Test for Conceptual Understanding in Momentum and Collision**

Level of Conceptual Understanding	Explanations	Score
Complete Understanding	First tier is correct, Second tier is correct, and third tier is I am sure of my answer	5
Partial Understanding without Alternative Conception	First tier is correct, Second tier is correct, and third tier is I am not sure of my answer	4
Partial Understanding with Alternative Conception	First tier is correct, Second tier is incorrect, and third tier is I am sure of my answer.	3
	First tier is incorrect, Second tier is correct, third tier is I am sure of my answer.	
	First tier is incorrect, second tier is correct, and third I am not sure of my answer.	
	First tier is correct, second tier is incorrect, and third is I am not sure of my answer.	
Alternative	First tier is incorrect, Second tier is incorrect, and third tier is I	2

Conception	am sure of my answer.	
	First tier is incorrect, second tier is incorrect, and third tier is I am not sure of my answer	
No Understanding	First tier is correct, second tier is correct, and third tier is I completely guessed my answer.	1
	First tier is correct, second tier is incorrect, and third tier is I completely guessed my answer.	
	First tier is incorrect, second tier is correct, and third tier is I completely guessed my answer.	
	First tier is incorrect, second tier is incorrect, and third tier is I completely guessed my answer.	

## RESULTS AND DISCUSSION

### Internal Consistency

During the first pilot testing the internal consistency using Cronbach's Alpha under SPSS was measured at 0.546 which means that test instrument is not good standardized test. Therefore the instrument underwent item analysis and revisions. The test items that were revised are 1, 5, 9, 12, 16, and 18.

**Table III  
Result of First Pilot Testing**

Parameter	Alpha	Mean	SD
First Pilot Testing	0.546	23.96	4.89

As seen in table 3.1, the computed Cronbach's Alpha is 0.546 with mean of 23.96 and standard deviation of 4.89. This computed alpha means that the test instrument is poor. According to Dennick and Tavakol (2011), test instrument with Cronbach's alpha of 0.5 to 0.6 is a poor test instrument.

After revision, the new test instrument was formulated and subjected for second pilot testing. This time the pilot testing was conducted in another school. Same administration procedure was done like in the first pilot testing.

**Table IV  
Result of Second Pilot Testing**

Parameter	Alpha	Mean	SD
Second Pilot Testing	0.706	46.83	6.25

The results of second pilot testing were collected. The result showed that the Cronbach's Alpha is 0.706 with mean of 46.83 and standard deviation of 6.25. This result means that the test instrument is now a good test for conceptual understanding in momentum and collision. According to Nunnally and Bernstein (1994), Bland and Altman (1997), DeVellis (2003), and Dennick and Tavakol (2011) for test instrument to be considered standardized and good instruments, Cronbach's Alpha must range 0.70 to 0.95.

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## CONCLUSIONS

Based from the result of validation, it can be concluded that the developed test for conceptual understanding in momentum and collision is reliable and valid can be called a standardized test. The instrument underwent three stages: development, pilot study, and validation before packaging the test.

The instrument was subjected to two pilot study. During the third pilot study, the instrument was standardized as the Cronbach's alpha was measured at 0.706. This means that the Three-Tier Test for Conceptual Understanding in Momentum and Collision is good as a test instrument.

This test will be helpful to physics teachers in collecting misconceptions, diagnosing difficulties in learning, and measuring conceptual understanding with respect to momentum and collision.

The topics' momentum and collision were proven to be difficult by many teachers, students, and literature. Therefore, this test can be diagnostic tests to measure what students already learned based from this previous experience and discussion. The Three-Tier Test for Conceptual Understanding in Momentum and Collision will be able to diagnose misconceptions and misunderstanding about the said topics in physics.

Furthermore, the test can be as summative test to assess the holistic development of the students during the discussion and activity in momentum and collision. The test will verify the complete understanding of the students pertaining to the topics.

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