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Students' representation about Newton law: consequences of "zero intuition"

Jeffry Handhika[1], C. Cari[2], A. Suparmi[3]

[1]Graduate Students, SebelasMaret University, IKIP PGRI MADIUN,
Jl. Setiabudi No. 85, INDONESIA,

[2,3]Physics Department of Post Graduate Program SebelasMaret University,
Jl. Ir. Sutami 36A KentinganJebres Surakarta 57126, INDONESIA

e-mail: jeffry.handhika@yahoo.com

Abstract. Newton's laws can represent in the language of verbal, mathematical, physical, and visual. Students who understood concept would express the concepts in various representations consistently. In this research, a mathematical presentation used to reveal the student's concept understanding about Newton first law. The results showed that 21.87% of the students changed the mathematical presentation of Newton's first law ($\sum \vec{F}$=0) into verbal representation incorrectly. Changing the mathematical form of Newton's first law into the form of (0=$\sum \vec{F}$) caused the percentage of students who did not respond increased, further concluded that "zero intuition" in the equation of Newton first law caused misconceptions.

1. Introduction

Understanding of Newton's laws has been discussed intensively by physicists and physics educators [1, 2, 3, 4, 5, 6]. Understanding of physics language, mathematics, visual, and intuition is the key to understanding physics concept [7]. Misconceptions and incorrect conception can occur if one language is not understood, or only one language that dominates over the others when taking conclusions. For example, if the mathematical language is dominant in explaining the concept, it causes incorrect conception [4, 5]. This condition will be reinforced in this research when equalization of the "zero" in the mathematical representation of Newton's law with "nothing" such that causes different verbal representations.

In fact, there are three types of the meaning of "zero" in the equation of Newton firs law. Zero as (1) the "zero intuitive", which means "nothing", (2) a "zero number" which used to represent numbers and (3) a "mathematical zero" according to modern mathematics [8]. "Zero intuitive" has extraordinary consequences in physics. Newton first law, for example, students can interpret that no forces are acting on the object [2]. This concept could certainly cause misconceptions on the student. In mathematics, Zero is a member of the set count numbers, integers, real numbers, and complex numbers, zero is a separator between the positive numbers and negative numbers, zero is not said to be positive or negative, zero is a number that does not have a sign [8]. So, the mathematician does not define zero as "nothing."

In the language of physics, the zero appears because there are physical quantities are mutually eliminated, especially for vector addition. In Newton's first law ($\sum \vec{F}$=0), "zero" appears because the algebraic operations of the net force acting on the object are zero. In mathematics, the "zero" can also obtain from the operation of algebra, variables such as x multiplied by y produces "zero" if both x and y are equal to zero, and x or y is equal to zero [5]. In Newton's second law ($\sum \vec{F}= m.\vec{a}$), $\vec{a} = 0$, then the equations and statements going back to the Newton first law. If m = 0, although mathematically produce a value of zero, Newton's laws do not apply, because the mass (m) is not the result of algebraic operations, mass is physical quantities. Newton's third law is not the same as Newton's first law, and most important is not another form of Newton's first law [9]. The Newton's first law can be another form of Newton Second Law [10], with consequences mass of the object should not be equal to zero.

Understanding of the language of mathematics and physics should be understood comprehensively if one language is more dominant over the other lead to occur incorrect conception. As a result, inconsistencies concept can raise cognitive conflict. Cognitive conflict can potentially cause misconceptions [7] and can cause anxiety if it not managed properly. Students Verbal representations have investigated by using mathematical presentations ($\sum \vec{F}$=0), cognitive conflicts raised by providing other forms of mathematical presentation (0=$\sum \vec{F}$).

2. Methods

This research method is descriptive qualitative. Subjects in this study were students at the IKIP PGRI Madiun who take a course in mechanics (32 students). Data collected through the test, where the students have to represent mathematical equation into verbal representation. In turn Verbal representations obtained are retested by giving a mathematical presentation in another form. Then finally unstructured interviews on students conducted to clarify the student answer (reasoning of his/her representation) [11, 12].

3. Results and Discussion

From the 32 students, there are 71.87% of students could represent the concept verbally and correctly, it found that there are two types of incorrect verbal representations.

Table 1. Percentage of verbal representations for $\sum \vec{F}$=0

Presentation	**Verbal Representation**	Percentage **(%)**
$\sum \vec{F}$=0	**Correct Representation**	
	Net force equal to zero, forces are acting on the object with the resultant forces are equal to zero	71.87
	Incorrect Representation	
	Type 1: Force equal to zero, there is no force acting on the object	6.25
	Type 2: The net force is equal to zero, meaning there is no force acting on the object.	15.62
	No Response	
	No response	6.25

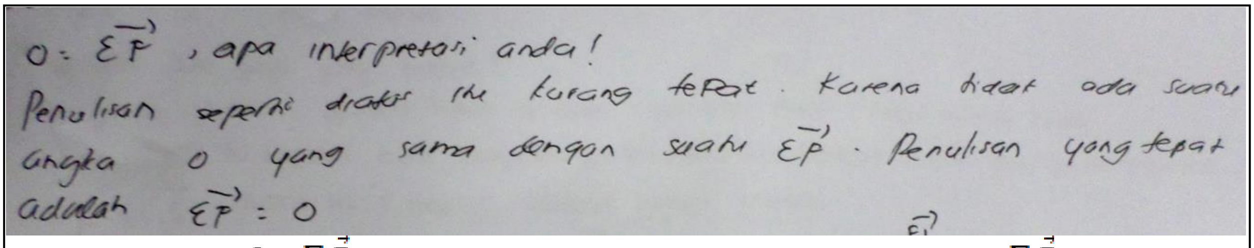
Incorrect Representation type 1 caused by the students who are not reading the mathematical symbol (sigma) and has a "zero intuition." In type 2, the students understand the mathematics language partially, and they still have "zero intuition." Another mathematical representation is given to evaluate verbal representations which reported by students (Table 2).

Table 2. Percentage of verbal representation for $0=\sum\vec{F}$.

Presentation	Verbal Representation		Percentage (%)
$0=\sum\vec{F}$	**Correct Representation**		
	"Zero" equal to the net force, forces are acting on the object with the resultant of forces are equal to zero		31.25
	Incorrect Representation		
	Type 1.	Zero is equal to the force; there is no force acting on the object	6.25
	Type 2.	a. There is no force acting on an object is equal to net force b. The object stopped because there is no force, if there is a moving object, the object has force.	9.37
	Type 3.	Mathematically, the equation is the same shape	3,12
	No Response		
	No response		50,00

The percentage of correct representation has decreased from 71.87% to 31.25% due to changes in the form of a mathematical presentation $0=\sum\vec{F}$. (Table 2); based on the interview, there was information that the students are confused in representing the mathematical equation. An example of the interview described below:

Lecturer : Why not give a response?
Student : I'm confused, sir
Lecturer : Try to express what you're confusing?
Student : Zero may not be the same as net force
Lecturer : Why? Can you give an explanation?
Student : Only this time I found zero equal to net force, this looks unusual. In physics, books not described the mathematical form like this.
Lecturer : What do you think? Can you express your argument?
Student : wait a minute, sir, (students write down their arguments) (Fig. 1).


$0 = \sum\vec{F}$, apa interpretasi anda!
Penulisan seperti diatas itu kurang tepat. karena tidak ada suatu angka 0 yang sama dengan suatu $\sum\vec{F}$. Penulisan yang tepat adalah $\sum\vec{F} = 0$

Writing as above it ($0=\sum\vec{F}$) was not quite right because there is no "zero" equal $\sum\vec{F}$. Appropriate writing is $\sum\vec{F}=0$.

Figure 1. The students write arguments

On the argument of type 1 (Table 2), students have misconceptions, because intuition is more dominant than others to get the conclusion. Besides that, The students also do not understand the mathematical language well. In type 2, intuition still dominates, although the mathematical language also appears to explain the verbal representation of Sigma. The dominance intuition, in this case, may cause a misconception. Intuition comes from the students themselves, simultaneously together with the conception that possessed by students, and able to answer problems that arise in him at that time. Type 3, mathematical language is more dominant than any other language.

Physics language more dominant than mathematical language to make decisions of presentation (Fig.1), the student not confident that the presentation of $0 = \sum \vec{F}$ is correct in physics because the student's never discovered a form of the equation $0 = \sum \vec{F}$ in the physics book. Understanding mathematics and physics language comprehensively help the student to get incorrect concepts. Changes in the mathematical presentation caused a significant impact on student representation. Cognitive conflict arises because there is the unusual presentation ($0 = \sum \vec{F}$). Students who have an understanding of mathematical language better than physics language argued that the form of presentation $\sum \vec{F}=0$ is equal to $0 = \sum \vec{F}$ be the same equation mathematically, without detailed explanation.

Physics can represent in four languages, (1) intuition, (2) mathematical (symbols and graphics), (3) communication, (4) physics language. All must be understood comprehensively. The misconception may occur if the language of intuition is more dominant than the other three languages. Incorrect conception occurs when the communication and mathematical language is more dominant. The dominance of using physics language can cause the student cannot provide a detailed explanation, domination of mathematical language causing physical limitations of the delivery of verbal language.

4. Conclusion

Zero intuition leads the students experiencing misconceptions. In Newton's laws, zero intuition can appear on Newton first and second law. In Newton's first law, zero intuition led to misconceptions on the student. The mathematical presentation can be used to identify students who experienced zero intuition. Changes the form of mathematical representation led to cognitive conflict. Students who experience zero intuition will argue with intuition languages. Introducing mathematics, physics, and intuition language comprehensively is the one way to prevent zero intuition.

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