Using word-pictorial presentation model to simplify understanding concept test of Newton’s law

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Abstract. The information in the presentation of the test is a factor that affects student’s response; it can be the correct or incorrect answer. Assume that students already know the information for an example speed. If the questions related to kinematics, then the chances of students answered correctly are greater than if it related to the dynamics. This potential is used principally to Simplify Student Understanding Concept Test of Newton's Law. FCI (Force Concept Inventory) numbers 13 and 14 used as a comparison of Word- Pictorial WPP model. WPP model applied to the students who take the course of mechanics (22 students). Obtained a positive correlation between WPP and FCI numbers 13 and 14, with value of $r_{13} = 0.72$, $r_{14} = 0.88$. It can conclude that the WPP model could be used as an alternative assessment to assess student understanding concept of Newton's Law

1. Introduction

Not all questions of FCI [1] can be understood by the student well, caused not all questions were answered correctly by the students. Question FCI contains WPP that presents information about the physical quantities of material content directly or indirectly. Assume the amount of speed already known by students, rationally; the opportunities students can answer questions related to kinematics greater than dynamics. It would be Easier for students to deciding the correct answer If the students already know the information, but if the presentation that requires the integration concept, it is difficult, for students to selecting the correct answer.

The information can be shaped as presentation words, verbal, images, graphics, and mathematical symbols. Furthermore, information will be filtered and included in the working memory [2]. Integration of it and prior knowledge raises student information which used to deciding the answer (Fig. 1). The process of integration of verbal information modeling, Picture, and prior knowledge enables intuition involvement in generating new information. If it is received is different from the initial knowledge possessed by students, it will bring cognitive conflict. The negative impact of cognitive conflict is the emergence of anxiety that caused the student has difficulty in deciding the answer or may not answer.
Prior knowledge, information model, and intuition are the three essential factors in the decision answers to the questions given. FCI is well used to evaluating understanding of force concept [3] and conceptual coherence [4] but has the disadvantage, the number of the questions (28) would require more time when implemented in learning. Development of an evaluation tool based on the presentation contained in the FCI is needed.

The use of the image has a stronger effect than the words. Memory stored in the form of images is more durable than the word [5]. Students will further develop the meaning behind the pictorial presentation more than words [6], and auditory stimuli are more accurately recalled than visual [7]. Presentation in the form of images and words has the advantages of each. On this test model, it displayed overall.

2. Methods
This research is a basic stage to develop the instrument more efficient than the FCI. The first step is analyzing the parts of a question on FCI. The parts that exist in the FCI profiled as a reference to develop a model of WPP. The final step is testing the model of WPP to 22 students who take a course in mechanics. FCI score numbers 13, 14 are used to validate WPP. Comparing FCI test with other tests ever conducted by other researchers [8, 9]. FCI numbers 13 and 14 are Newton's Third law which Newton first law as a distractor. Both problems have been due to the findings of previous studies [10], that students have the conception that Newton's first law is an another form of the Newton third law, so they concluded that Newton first law is equal to Newton third law.

3. Results and Discussion
3.1. First Step, analyze the parts of a question on FCI
FCI question number 13 (Fig.2) [1] relating to Newton's third law, the information presentation physical quantity "speed" in a "word" and "image" (interaction cars). To answer this question, students must understand the relationship between speeding up and force.

![Figure 1. Cognitive Theory of Presentation, adapted from [2]](image)

![Figure 2. Question FCI Number 13](image)
There are four parts in question FCI (Fig. 2). Part (1) is the information presented through WP that describes the command to complete the test and the events of the PP. Part (2) is a PP which describes the events which were described by WP. Presentation (1) and (2) are mutually reinforcing so that the students more easily understand the events. Part (3) a WP that provides physical quantity information "Speeding up" and "speed," were associated with kinematics, and then "pushing" was related to dynamics. PP shows an object interaction. Based on the information, the students have opportunities to conclude that this case is Newton's third law, but it would be different if the multi-presentation presented cause anxious, students would be unable to integrate all presentations. In FCI number 14, reinforced with a WP which presented physical quantities "constant speed" as a distractor (Fig. 3) [1].

Figure 3. Question FCI Number 16 with WP as a distractor

WP as a distractor makes students confused in choosing an answer. For students who have misconceptions and believe that in the Newton’s first law “no forces are acting on the object,” then they will choose the answer (E) because it makes more sense for them. For students who have a conception that mass influences forces of action-reaction, then they will choose answer (B), while the answer (C) selected because they have the intuition to assume that high speed will produce a larger force. Students who not understand the concept of physics will choose Answer (D). For students who understand physics concepts well, the questions which submitted by the various presentations must have answered correctly [11]. For students who understand the concept partially will bring cognitive conflict and make it difficult for them to decide the answer [12]. Opportunities to get an incorrect answer, for the students who understand the concept partially [11].

3.2. Second Step, create WPP model which considering the parts of FCI questions

In the first step, it has explained that the FCI has four parts, (1) WP, (2) (PP), and (3) (CWP). In exceptional cases, WP may act as distractors. WP and PP presented simultaneously based on the research [4, 5, 6]. CWP is not used to develop this model because the student's conception should not be restricted. WPP model results as follows:

Figure 4. WPP Model
3.3. Testing the model of WPP

Model of WPP tested to 22 students who take a course in mechanics. The result of the test (Table. 1a, 1b) shows that the student's partially understanding about Newton’s law.

### Table 1a. Students answer about Newton’s Law, before Discussion

| Choice case | Answer (%) |
|-------------|------------|
| 1           | 0.09       |
| 2           | 0.18       |
| 3           | 0.09       |
| 1 & 2       | 0.18       |
| 1 & 3       | 0.14       |
| 2 & 3       | 0.32       |
| 1, 2, & 3   | 0          |

### Table 1b. Students answer about Newton’s Law, after Discussion with peers

| Choice case | Answer (%) |
|-------------|------------|
| 1           | 0.14       |
| 2           | 0.09       |
| 3           | 0.14       |
| 1 & 2       | 0.23       |
| 1 & 3       | 0.41       |
| 2 & 3       | 0.14       |
| 1, 2, & 3   | 0          |

WPP positively correlated to the FCI test (Table 1). FCI score numbers 13, 14 are used to validate WPP. This numbers will be answered correctly by the students who understand Newton's first and third law well. Problem WPP requires the ability to understanding of Newton's first and third law. FCI Question number 13 gives the correlation value smaller (0.72) than question number 14 (0.88). The information is presented in number 13 more detail, not caused student’s anxiety so that they can get the correct answer easily. In the model of WPP, understanding the concept of the students can be identified more detail, because students are required to provide arguments of their options. The argument that has been presented by the students can be used to identify students' understanding of the concept (Figure 5a, 5b).

From the arguments had presented, many students still choose case 2 and 3 (0.32%) (Table 1a). Case 2 and 3 chosen because according to the textbooks information and examples are given by the teacher while they were in high school level. Many teachers cited Newton's first law as “a car braking process” so that many students conclude that Newton's first law on the choice of b and c. The students assume inertia as an object that maintains its position (Fig. 5.a) and the objects at rest, then moving and stopped (Fig 5.b). After being given the time to discuss with peers, with problems to distinguish between case 2 and 3, caused student changed the answer choices, selection of case 1 and three is more dominant (Table 1b). Arguments students (Fig. 6) provide information that the discussion helps students to find the correct concept.
After the discussion, which was initially only chosen case (1) as Newton's first law, transformed into (1) and (3), because they get information about the constant speed and definition of inertia. Case (3), initially answered Newton's second law, and then converted into Newton's first law when viewed from the small box.

Figure 6. Example Answer Student after discussions with peers

Still found that the students who did not select an answer, and convinced the case (2) as Newton's first law. Not easy to change the conception of students who already stored in its memory. Car braking events which visualized in the textbooks are information that goes through the dual channel stored in long term memory. Cognitive conflict through discussions has been conducted to examine and clarify the prior knowledge of the students. They can change the answer choices. In the case of (1) rarely exemplified in the learning process in high school, and not found in everyday life, so it can be difficult for students to understand Newton's first law. Case (1) are found in textbooks and presented in textual presentation, and delivered verbally by most teachers, but not exemplified the event in detail. These events can only exemplify in the laboratory scale. Also found students who answered the case (3), arguing that the case (3) be the third Newton's laws. Action and reaction can occur in a small box and a large box, but the arguments have presented by the student is not appropriate.

4. Conclusions

WPP can use as alternative tools to measure student understanding concept of the Newton’s law. The arguments submitted by students is one of the strengths of this model. Found information that is giving the example of Newton's laws for “a car braking event” is represented differently by the student. Students represent the case as Newton's first law without considering the condition and which objects observed. Information delivered from textbooks, and teachers or lecturers are not examined more deeply by the students. Recommended for teachers and lecturers to submit an example of Newton’s laws in detail and clearly and maximize the learning activities at the laboratory to describe the ideal conditions of physics.

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