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The Effect of Language in Students' Performance in FCI

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Abstract: This is a study on the performance of freshmen college students in a standard test, the Force Concept Inventory. In particular, the effect of language was explored. Two versions of the test, the original English FCI and the translated Filipino version, were given at random to 381 students. It was found out that there was no significant difference in the mean scores of the students (mean = 8.3 for English version and 8.1 for Filipino version, max = 30). These values were within the typical scores of students in beginning physics classes from other countries. Except for 4, the rest of the 30 items in the test had difficulty indices of less than 0.50, indicating a difficult test. Not surprisingly, the discrimination indices of the items were also low. The English version had slightly higher discrimination indices in 2/3 of the items. This is most evident in the items involving Newton's third law.

Key Words: FCI; Filipino version; student performance; difficulty index; discrimination index

1. INTRODUCTION

Assessment plays a crucial role in the students' learning processes. Standardized tests are commonly used to assess student's conceptions prior to instruction. In physics, one of the most popular standard concept tests is the Force Concept Inventory (FCI) of Hestenes, Wells and Swackhamer (1992, later revised by Halloun, Hake, Mosca and Hestenes, 1995). Although there have been debates about what FCI really is (or is for), it is generally agreed that FCI is very useful both in education research and pedagogy. FCI is a 30-item multiple choice test that probes students' (mis)conception of force and motion. It is used as a diagnostic test by many physics teachers in high schools and colleges.

To date, FCI has been translated to 25 different languages, including Filipino (Jackson, 2015). This paper seeks to explore whether language affects the performance of the college students in FCI. It is possible that students' answers are affected by their comprehension of the question and/or the choices.

2. METHODOLOGY

This is a descriptive study on the performance of freshmen engineering students in a standard test in force and motion. Eleven sections of beginning physics classes were selected, with a total of 381 respondents. Test administration was done during the beginning of instruction in a basic mechanics course. The distribution of the respondents according to the version of the test (original English or translated Filipino) taken is shown in Fig. 1.

The standard test Force Concept Inventory of Hestenes and Haloun (1995) and its Filipino translation were used in this study. Details of the translation of FCI to Filipino version can be found in an earlier work (Tadeo and Roleda, 2013). The

translated version was found to be parallel to the original English version. Figure 2 shows a sample item for the English version and the translated Filipino version.

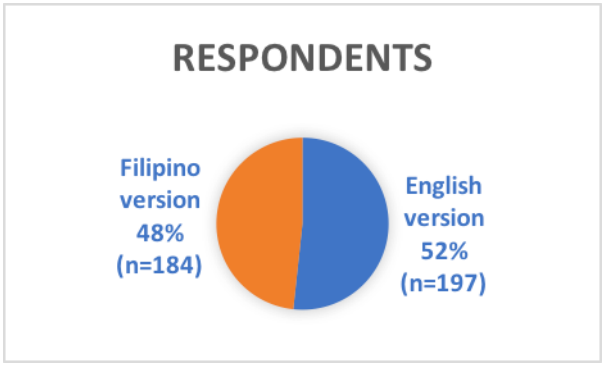

Fig.1. Distribution of respondents in the 2 test versions

The answers of all respondents from each group (English and Filipino) were considered for item analysis including item difficulty index, p-value, mean scores, standard deviation, etc. However, only the responses of the top and bottom 27% from each group (Green, 2013) were taken into account for the discrimination index, D.

4. A large truck collides head-on with a small compact car. During collision:

(A) the truck exerts a greater amount of force on the car exerts than the car exerts on the truck.
(B) the car exerts a greater amount of force on the truck than the truck exerts on the car.
(C) neither exerts a force on the other, the car gets smashed simply because if gets in the way of the truck.
(D) the truck exerts a force on the car but the car does not exert a force on the truck.
(E) the truck exerts the same amount of force on the car as the car exerts on the truck.

4. Ang isang malaking trak at ang isang maliit na kotse ay harapang nagbungguan. Sa bungguan:

(A) ang pwersang mula sa trak ay mas malaki kaysa sa pwersang mula sa kotse
(B) ang pwersang mula sa kotse ay mas malaki kaysa sa pwersang mula sa trak
(C) walang pwersang nagmula sa dalawa; ang kotse ay nayupi dahil ito ay humarang sa daanan ng trak
(D) nagmula lamang ang pwersa sa trak at walang nagmula sa kotse
(E) ang pwersang nagmula sa trak ay kasinlakas ng nagmula sa kotse

Fig. 2. Sample item of FCI in the original English version (top) and the translated Filipino version (bottom)

3. RESULTS AND DISCUSSION

Figure 3 shows the distribution of scores of the respondents in the FCI. It is evident that the distribution is positively skewed (skewness = 1.13), indicating a low performance of the students. The mean score is 8 (max. score = 30) with a standard deviation of 3.7.

The comparative performance of the students in the 2 FCI versions is shown in Fig. 4. Scores range from 0 to 21 (max. = 30) for the English version while the range is 1 to 25 for the Filipino version. The mean scores were 8.3 and 8.1 with standard deviations of 3.9 and 3.5, for English and Filipino versions, respectively. A t test showed there was no significant difference in the mean scores at p = 0.05. This supports the earlier assertion of Tadeo & Roleda (2013) that the 2 versions of the test are equivalent.

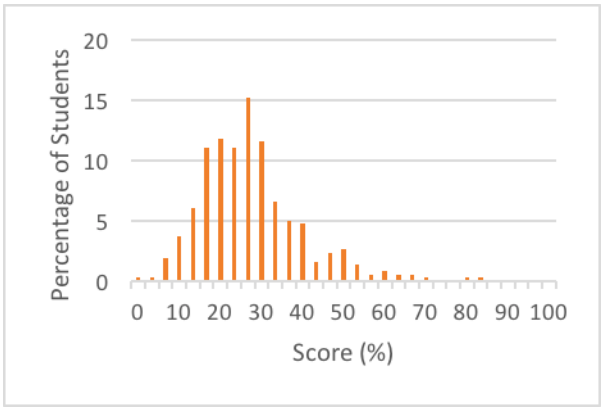

Fig. 3. Combined distribution of Scores of Respondents in the 2 FCI versions

In addition, this mean score of about 27% is higher than those reported in international literature: 20%, obtained from first year engineering students in Indonesia (Cahyadi, 2004); 20%, from college students in Laos (Luangrath, Pettersson & Beckert, 2011); about the same mean score, 28%, for IB students from Finland (Savinainen & Scott, 2002); and high school students from Croatia, mean score = 27% (Planinic, Ivanjek & Susac, 2010); but lower compared to science and engineering students from the University of Minnesota, mean score ~50%, (Docktor & Heller, 2008).

Results of item analysis for the difficulty index for the 2 versions are shown in Figs. 5 and 6.

The difficulty indices of the corresponding items in both versions are about the same. Save for items 1, 6, 7, and 12, all items have difficulty index lower than 0.5 indicating that the items were difficult. This is apparent in Figure 6 where the distribution of the items according to the difficulty indices obtained is shown.

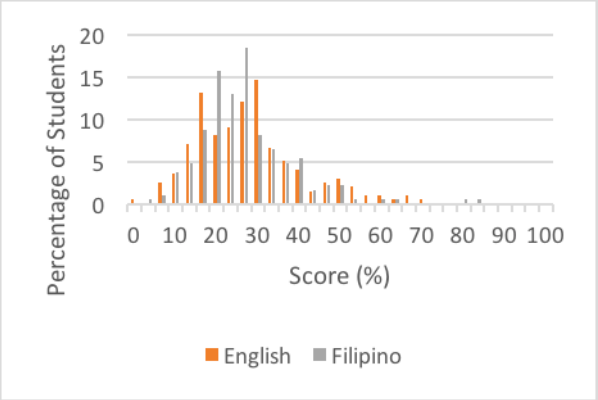

Fig. 4. Comparative Distribution of Scores

Only item number 12 was found to be somewhat easy for the students, with a difficulty index of 0.61. This item involves the path of a projectile which is commonly taught in beginning physics classes. On the other hand, items 11, 13, 18, and 26 have difficulty indices of lower than 0.1 ($p = 0.07$ for items 11, 13, 18 and $p = 0.04$ for item 26), indicating less than a tenth of the students answered these items correctly. The 3 items involve gravitational force while the most difficult item deals with force and velocity.

It is interesting to note that for each of these items the distribution of the answers of the students among the choices were practically similar for both versions. For these items, the students' conceptions appeared to be consistent regardless of the language the problems were presented. See, for example Table 1 for item 13.

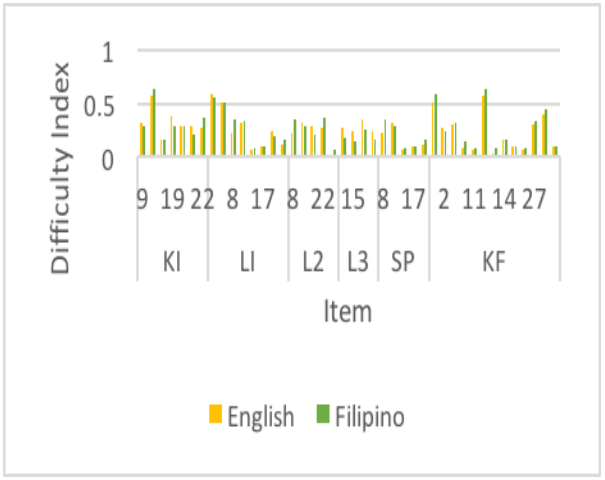

Fig. 5. Difficulty index (legend: KI – Kinematics; L1 – Newton's first law; L2 – Newton's second law; L3 – Newton's third law; SP – Superposition principle; KF – Kinds of force)

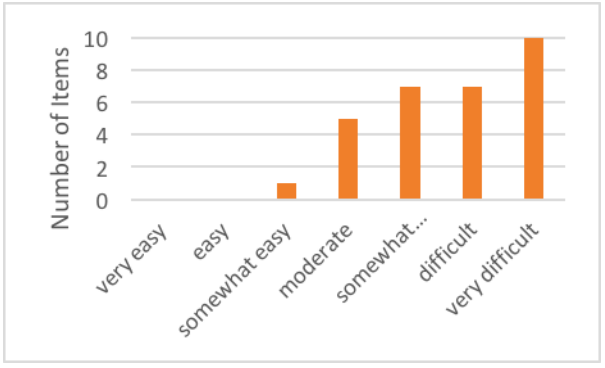

Fig. 6. Difficulty level of the items

This item probes the understanding of students regarding free fall with the object initially thrown vertically upward. In both versions of the test, almost half of the students from each group thought that there is a decreasing upward force on the object as it goes up and an increasing gravitational as the object goes down. The next most popular answer was "C." The students believed there were both upward and downward forces as the object goes up but the upward force decreases until it is zero at the highest point of the object and as the object goes down there is only a downward force. About 10% of the students from both groups regarded that there are both the upward and downward forces

on the object during its flight but the upward force decreases. The correct answer (D) ranked only fourth, there is a constant downward force throughout the flight. Not surprisingly, the least attractive choice reflects the idea that objects fall to the earth because of the "object's natural tendency to rest on the surface of the earth," a very Aristotelian idea.

Table 1. Percentage of students who answered the corresponding choices in the English and Filipino versions of FCI

item 13	English	Filipino
A	7.11	14.21
B	49.24	47.54
C	39.09	27.87
D	4.06	9.29
E	0.51	1.09

As expected, the values of the discrimination index, D, were low. Difficult items do not discriminate students' performance – both top and bottom groups of students perform generally poorly in the test. The discrimination indices of the corresponding items for the 2 versions of FCI did not show any remarkable pattern (see Fig. 7).

It must be pointed out, however, that about two-thirds of the test items had discrimination indices higher for the English version. In particular, for each of the four items regarding Newton's third law (L3), $D_{English} > D_{Filipino}$. This observation was also true for the corresponding difficulty indices of these items, that is, $p\text{-values}_{English} > p\text{-values}_{Filipino}$. Although in the previous discussions language did not seem to have an effect in the students' answers, the converse appears to be true for this case. A possible reason for this is that the concept of Newton's third law necessitates "reciprocation" wherein same set of words are used with a slight variation. This can result to confusion. For example, "the magnitude of the force *on the book excerted by the hand* is equal to the magnitude of the force *on the hand exerted by the book*." The same set of words are used with the "doer and recipient of the action" reversed. Furthermore, the Filipino translation of these words tend to be too lengthy that was likely to result to further confusion.

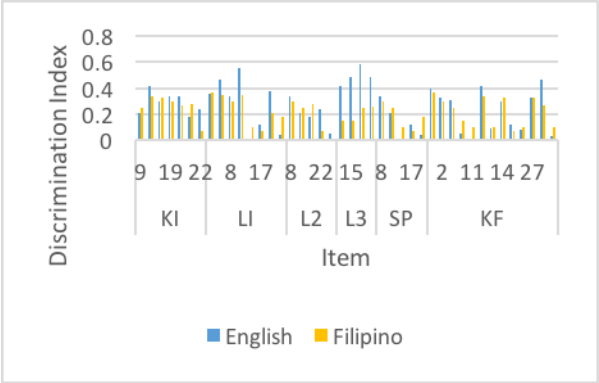

Fig. 7. Discrimination index (legend: KI – Kinematics; L1 – Newton's first law; L2 – Newton's second law; L3 – Newton's third law; SP – Superposition principle; KF – Kinds of force)

Below are the transcripts of the comments of some students who were not able to answer any of the 4 L3 items correctly:

> *"The Filipino version appears to be more difficult because some words are confusing and students are not comfortable in using the Filipino language in subjects such as Physics."*
>
> "*…Merong mga salita na kailangan na linawan at palitan ng mas angkop na salita upang ito ay maging ganap na teknikal at madaling maintindihan*" (*Some words need to be clarified and even modified to sound technical and easy to understand.*)
>
> *"… I struggled a little and had a hard time understanding the questions because I am not used to dealing with questions that are in formal Tagalog."*
>
> *"(I) am more used to English problems"*

4. CONCLUSIONS

The performance of college students in a standard test was studied. Their scores in the original English Force Concept Inventory and its

translated version were compared. Results of a t test showed that there is no significant difference in the mean scores of the students in the 2 versions. In addition, the difficulty indices for corresponding items (for both versions) were about the same. These p-values, however, were very low (most < 0.5) indicating very difficult items. Due to low p-values of the items, the discrimination indices obtained were also low. Transcripts of students' comments showed that they were not used to answering a physics test in Filipino.

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