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TRANSLATION AND VALIDATION OF THE FORCE CONCEPT INVENTORY (FCI) IN FILIPINO

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Abstract: This study focused on the translation and validation of the standard conceptual survey Force Concept Inventory (FCI). The original English FCI was translated in Filipino using the conceptual translation model. Filipino physics teachers who are adept in English and Filipino then validated the translated FCI. Both original English and translated Filipino versions of the FCI were administered to 459 grade 10 students. These respondents belong to the top classes of each of the ten (10) public secondary schools in Makati. Chi squared test showed that the two versions are parallel. Also, using the F test, it was found out that language has no effect on the performance of the students. However, the performance of the students was generally poor. Majority of the scores range from 4 to 6, out of 30. In addition, the mean score (15.3%) of the local students from both tests were lower than the means scores of students from different international studies, i.e., Hestenes (1992) – 27%, Hake (1998) – 30% in USA, Jauhiainen, et. al (2001) – 58% and Savinainen (2003) – 28% in Finland, Pare (2008) – 30% in Africa, and Luangrath, et. al (2011) – 21% in Laos. Furthermore, the top five prevailing alternative conceptions of the local students were: Gravity increases as object falls; Inertial motion; Circular motion continuance; Position-velocity undiscriminated; and Velocity-acceleration undiscriminated.

Key Words: translation; force concept inventory; conceptual understanding; misconceptions

1. INTRODUCTION

Hestenes et. al (1992) have designed an instrument to probe students' beliefs related to concepts of mechanics called the Force Concept Inventory (FCI). The FCI is a multiple-choice test designed to monitor students' understanding of the concepts in Newtonian mechanics. It addresses six conceptual dimensions namely: kinematics, Newton's First, Second and Third laws, superposition principle, combined contact forces, and gravitational forces (Savinainen, & Viiri, 2003). It is composed of 30 conceptual questions that do not require calculations. Each item has five answers – one correct and four non-correct answers. The non-correct answers or distractors correspond to common student misconceptions that have been found in Physics research (Hestenes, 1992).

Recently, there have been a number of researches that work on FCI being translated into different languages and use it to identify conceptual understanding of students, or to evaluate of teaching methods (Jauhiainen et. al, 2001; Luangrath, et. al, 2011; Pare, 2008). In this study, the Force Concept Inventory (FCI) was translated in Filipino, validated and was used to evaluate the conceptual understanding of a group of public secondary school students. A possible "language effect" was also explored by probing the students' performance in Newtonian mechanics using

both the original English FCI and the Filipino FCI. Furthermore, this study sought to identify the level of conceptual understanding of Newtonian mechanics in Makati public secondary schools and compare it to other foreign results, and determine their common conceptions.

2. METHODOLOGY

Four hundred fifty-nine (459) grade 10 students from ten (10) Makati public secondary schools were the respondents of this study. The students are grouped into four namely, English-English (EE), English-Filipino (EF), Filipino-English (FE), and Filipino-Filipino (FF). The grouping corresponds to the version of FCI they took for administration 1 and administration 2 one week apart. The reasons for grouping the participants in this manner is to see if there is difference between English and Filipino versions, and difference between 1st and 2nd administrations. Test administrations happened on the 5th and 6th week of the School Year 2012 – 2013 (July 2 – 13, 2012). They have taken force and motion topics when they were in their 7th grade but have not yet restudied mechanics in their grade 10 high school physics course.

The original English FCI was translated using the conceptual translation model. The translator who is the researcher himself translated the FCI to the best of his ability that the Filipino translation remains faithful to the ideas and concepts being probed by the original FCI. The translator needed to consider the Filipino words students usually used in daily conversation. In addition, there are "loan words" – words that have been borrowed as whole and their meanings have been retained intact (Taljard, 2008). These loan words are the technical terms such as *gravity*, *acceleration*, *friction*, and *right angle*. This is because the student respondents are more familiar with the English terms than the seldom-used Filipino terms.

After a draft translation was made, it was presented to Filipino physics experts, physics teachers, and teachers of Filipino subject to review the translation in terms of semantics, grammar, and syntax. The translated Filipino version was then be revised in accordance with the recommendations of the validators. After which, it was shown to the validators for final comments. These comments were incorporated until the validators approve the translated version. Figure 1 below show how an item in English FCI was translated in Filipino. This item was easily translated for the English words have direct Filipino words. The sentence construction is retained, the stem ended with a question.

Isang bola ang ipinutok ng kanyon mula sa itaas ng bangin tulad ng ipinakikita ng larawan sa ibaba. Alin sa mga daan ang pinakaposibleng susundan ng bolang kanyon?

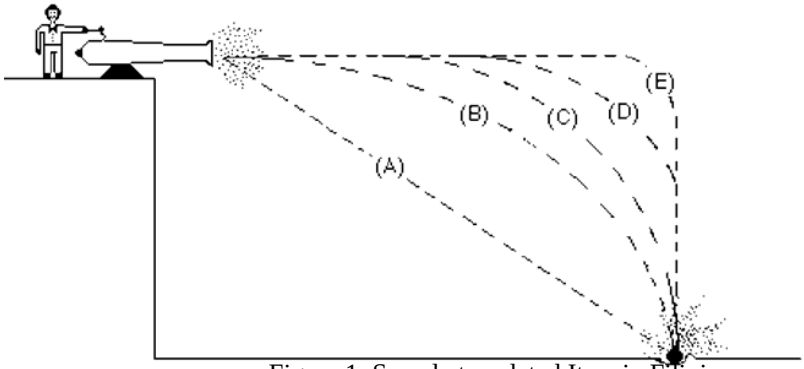
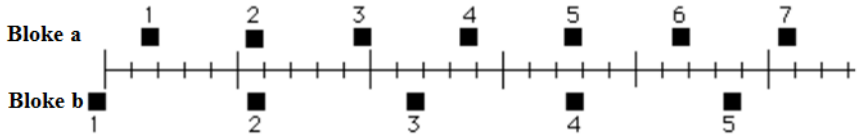


Figure 1: Sample translated Item in Filipino

Figure 2 below shows another translated item. This item was translated in the same manner such that common Filipino words were used but for this item, there were borrowed words to make the thought of the same. These "loan" words were acceleration and zero which are in italics below.

20. Ang mga posisyon ng dalawang bloke sa magkasunod na tig - 0.20 segundo ay ipinakikita ng mga parisukat na may bilang sa larawan sa ibaba. Ang mga bloke ay kumikilos patungo sa kanan.



Ang *acceleration* ng mga bloke ay gaya ng sumusunod:
(A) Ang *acceleration* ng "a" ay higit kaysa *acceleration* ng "b"
(B) Ang *acceleration* ng "a" ay pareho sa *acceleration* ng "b". Ang kanilang *acceleration* ay higit sa *zero*.
(C) Ang *acceleration* ng "b" ay higit sa *acceleration* ng "a"
(D) Ang *acceleration* ng "a" ay pareho sa *acceleration* ng "b". Ang kanilang *acceleration* ay *zero*.
(E) Hindi sapat ang mga impormasyong binigay upang masagutan ang katanungan.

Figure 2: Sample translation with loan words

3. RESULTS AND DISCUSSION

The final version of the translated Filipino FCI was given to twelve (12) Filipino physics experts and teachers who are adept in English and Filipino languages for validation. The validators were given copies of the original and translated FCI and compared both translations by reviewing the items of the translated Filipino FCI if they are acceptable and parallel to the original English FCI. They were given a rubric that assessed its acceptability. Most items were rated 8 out of 12 or above (70% - 100%) making them acceptable. Only items 15 and 16 were acceptable but with revision for these items are scored 7 and below (60% and below).

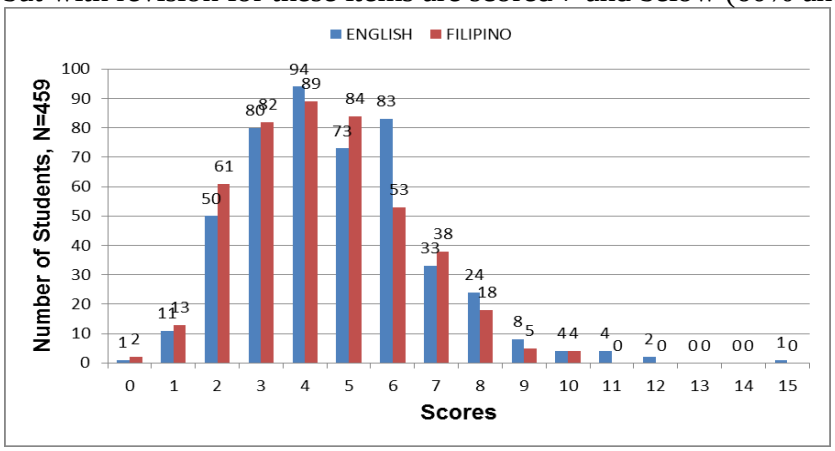


Figure 3: Distribution of scores of the combined test administrations 1 and 2 in English and Filipino FCI
*Maximum score is 30. Scores 16-30 are not shown since f=0

Figure 3 above shows the distribution of scores of the combined administration 1 and administration 2 of English FCI and Filipino FCI. The distributions of scores for both translations are similar suggesting that the translated Filipino FCI is parallel to the original English FCI which was confirmed by the shape of distributions plus by the Chi-square test run with PHStat2 giving a p-value of 0.98. Hence, the items in the translated Filipino FCI are parallel to the items in the original English FCI based on the evaluation of the physics teachers and experts, the shape of distribution and the Chi-square test.

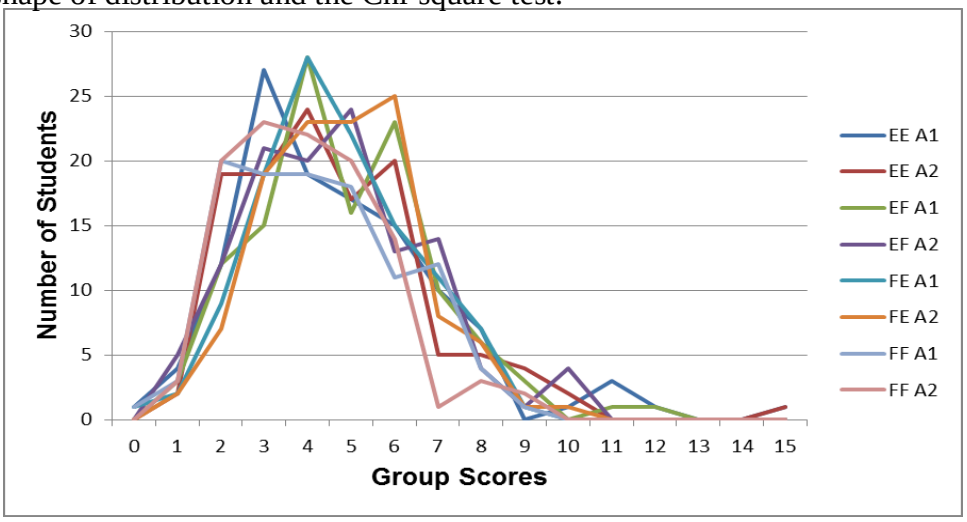


Figure 4: Group scores for test administrations 1 and 2
*Maximum score is 30. Scores 16-30 are not shown since f=0

Hestenes, et. al (1992) have proposed that the minimum level of understanding Newtonian concepts is given by Newtonian entry threshold equal to 60% (18 out of 30) of the maximum FCI score. Based on the results shown in Figure 4, the understanding of all the participants is below the entry threshold. The low mean scores may be attributed to the fact that the participants have studied "a little" of force and motion in their 7th grade and have not restudied the topics when they took test administrations 1 and 2 in grade 10 which is 3 years after they've taken force and motion. The participants have a mean score of 4.59 with percentage of 15.3% in test administration 1 that is lower than the entry threshold (60%) of understanding Newtonian concepts.

The mean percentage score for test administration 1 was 15.3% of the total FCI. The result obtained in this study using the original English FCI and the translated Filipino FCI for test administration 1 equal to 15.3% is significantly lower than the pretest mean score percentages in the previous studies of Hestenes (1992) – 27%, Hake (1998) – 30% in USA, Jauhiainen, et. al (2001) – 58% and Savinainen (2003) – 28% in Finland, Pare (2008) – 30% in Africa, and Luangrath, et. al (2011) – 21% in Laos. Hence, the grade 10 students in Makati have poor level of conceptual understanding of Newtonian mechanics compared to the foreign students subjected to earlier studies on FCI.

Roleda (1999) used the FCI to identify the alternative conceptions of the De La Salle University physics students by getting the average misconception index of each alternative conception. Each alternative conception are scored if is corresponds to the response of the students. The score was summed up and divide it by the total number item representing each conception. Using the test administration 2 results, the average misconception indexes were obtained. Figure 5 presents the participants in this study significantly carry the alternative conception G4 (Gravity increases as object falls) – 61%.

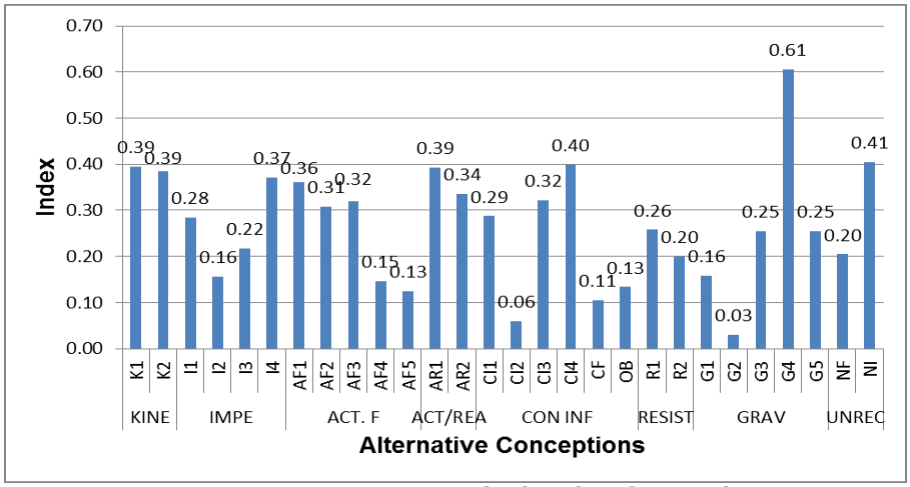


Figure 5: Average Misconception Index based on the test administration 2

According to Hestenes, et al. (1992), gravity is not necessarily the same as the gravitational force in the commonsense world. It is believed that gravity significantly varies over a few meters. Alternative conceptions CI4 (Circular motion continuance) and NI (Inertial motion) are also prevalent with indexes 40% and 41 % respectively. Most of the students think that if a steel ball attached to a string and is swung in a circular path in a horizontal plane and the string suddenly breaks, it will continue to move in a circular path. Hence, confirming their problem of recognizing inertial motion. On the other hand, the alternative conceptions which had lowest indexes are CI2 (Force compromise determines motion) – 6% and G2 (Natural tendency of objects to rest on earth's surface) – 3%.

The Analysis of Variance (ANOVA) was used to determine if there is a significant difference between test administration 1 mean scores and test administration 2 mean scores of the four groups using Microsoft Excel 2010. Figure 6 presents the ANOVA of test administration 1 means. It gives a p-value of 0.15 that is greater than alpha level of 0.05 that suggests that there is no significant difference between the test administration 1 mean scores. Hence, all the groups performed the same in answering the FCI.

SUMMARY

Groups	Count	Sum	Average	Variance
EE	118	556	4.711864407	6.104302477
EF	118	570	4.830508475	4.193249312
FE	115	531	4.617391304	3.185659802
FF	108	457	4.231481481	3.693579093

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	22.43353265	3	7.477844218	1.733105866	0.159387686	2.624505785
Within Groups	1963.19174	455	4.31470712			
Total	1985.625272	458				

Figure 6: ANOVA of test administration 1 mean scores

On the other hand, the ANOVA of test administration 2 mean scores shown in Figure 7 gives a p-value of 0.01 that is lesser than alpha level of 0.05 that means there is a significant difference between the test administration 2 means scores. It describes that the groups performed differently in test administration 2. The difference in the test administration 2 mean scores may be attributed to the version of FCI given.

SUMMARY

Groups	Count	Sum	Average	Variance
EE	118	544	4.610169492	4.992032
EF	118	549	4.652542373	4.262857
FE	115	553	4.808695652	2.998169
FF	108	433	4.009259259	2.925147

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	40.74886219	3	13.58295406	3.556762	0.014368273	2.624505785
Within Groups	1737.604079	455	3.818910064			
Total	1778.352941	458				

Figure 27: ANOVA of test administration 2 mean scores

The results prove that language doesn't affect the performance of the students in answering a test on Newtonian mechanics since the p-value for test administration 1 is 0.15 lower than alpha level 0.05 showing that there is no great difference in the mean scores of the four groups.

4. CONCLUSIONS

The level of conceptual understanding of Newtonian mechanics in Makati public secondary schools is equal to 15.3%. The participants in this study were only grade 10 students with average age of 15. Also, they have taken force and motion in their 7th grade and mechanics has not been taught yet in their current school year.

The result showed that the grade 10 students in Makati have poor level of conceptual understanding on Newtonian mechanics compared to the foreign students subjected to earlier studies on FCI. The common misconceptions probed were G4 (Gravity increases as object falls), NI (Inertial motion), CI4 (Circular motion continuance), K1 (Position-velocity undiscriminated), and K2 (Velocity-acceleration undiscriminated).

Moreover, it was found out that there is no significant different difference between the performances of students in the original English FCI and translated Filipino FCI. As such, language doesn't affect the performance of the students in answering the FCI test since there is no great difference in the mean scores of the four groups. Generally, students from Makati have poor conceptual understanding on Newtonian physics since the scores are below the Newtonian entry threshold of 60%.

5. ACKNOWLEDGEMENT

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