

A COMPARISON OF THE FCI SCORES OF AFGHAN AND MALAYSIAN STUDENTS WITH OTHER COUNTRIES

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Abstract

This article focused on the comparison of the performances of Afghan, Malaysian university students and the results of students from other countries using the Force Concept Inventory (FCI). There were 90 Afghan and 70 Malaysian university students who participated in this study. The collected data were analysed using SPSS v. 24 and Microsoft Excel. The results of this investigation showed that generally, Afghan and Malaysian students had low level of conceptual understanding of Newtonian mechanics which is less than the Newtonian entry threshold for FCI. The results showed that there is a significant difference between Afghan and Malaysian university students in the level of conceptual understanding, where the mean score of Malaysian students is 9 percent higher than that of Afghan students. The results further showed that the average score of Afghan is lower than the average scores of students from other countries such as USA, China, UK, Russia, Finland, South Africa, Turkey, Saudi Arabia, Thailand, India, Indonesia and Malaysian students is about the same range of students mean FCI scores from some countries such as Africa, Thailand, India, Turkey and Saudi Arabia. Finally, recommendations are made to improve students conceptual understanding in Introductory Physics as well as for further researches.

KEYWORDS: conceptual understanding, Newtonian mechanics, Afghan and Malaysian university students, Pashto and Malay versions of FCI.

INTRODUCTION

In the teaching and learning process, it is important to get an in-depth knowledge about the students' conceptual understanding and their misconceptions. According to Killen (2000) in each teaching method educators should give more emphasis on learning than teaching. Most importantly, educators should ensure that students' foundation knowledge is strong in order to enable them to understand important concepts and basics principles of physics. This is especially significant in the study of classical mechanics. Classical (Newtonian) mechanics or simply Mechanics is an important initial step in the learning of physics at the university level. Conceptual understanding is a necessary element of significant learning. Thus, conceptual understanding of Mechanics in its most fundamental form means understanding the principles of physics, physical phenomena and concepts because Newtonian mechanics is one of the central topics in introductory physics.

Many Research-Based Assessment Instruments (RBAIs) have been developed on the Newtonian force concept and related kinematics (Madsen et al., 2017; Van Heuvelen, 1991; Von Korff et al., 2016). The Force Concept Inventory (FCI) qualitative test was designed by Hestenes and his co-workers (Hestenes, 1992). It was then revised in 1995 by Halloun, Hake, Mosca, Hestenes, Wells and Swackhamer and has become an internationally well-known and widely used standardized conceptual test in introductory physics (Halloun et al., 2015; Mazur, 1999; Von Korff et al., 2016). Since then it has proven a valuable assessment instrument at all levels of introductory physics from school to university in Physics Education Research (PER) and has been used in many countries and cultures throughout the world. According to Hake (1998) and Savinainen and Scott (2002b), the FCI assessment instrument has had a substantial effect on introductory physics instruction in the USA. A number of instructional methods have been developed by using the FCI to determine the effectiveness of the manner of teaching (Scott et al., 2012). This instrument has 30 multiple-choice questions which covers the fundamental topics of Newtonian mechanics in six conceptual dimensions (Kinematics, Newton's First Law, Second Law, Third Law, Superposition Principle and Kinds



of Forces). In addition, the FCI was also used to assess teaching effectiveness in the introductory physics courses (Hestenes & Halloun, 1995; Hestenes et al., 1992; Mazur, 1999; Von Korff et al., 2016). According to the previous body of research, the difficulties of conceptual understanding are common among students. High School, undergraduate, graduate and postgraduate students are commonly found to have these misconceptions that are not scientifically accepted, also known as the alternative conceptions (I. A. Halloun & Hestenes, 1985; Sharma & Sharma, 2007; Van Heuvelen, 1991). Kim and Pak discovered that the students still had numerous well-known conceptual problems with basic Newtonian mechanics even after solving 1000 traditional problems in university physics courses (Kim & Pak, 2002). Many researchers have studied and used the FCI, the latest improved version of the FCI is available in 33 languages (Halloun et al., 2015).

In this investigation, the FCI Pashto and Malay 1995 versions are used to evaluate the conceptual understanding of a group of national students respectively, in Kabul, Afghanistan and in Shah Alam, Malaysia. This survey-based study helps instructors learn how to improve their teaching and to teach their students more effectively. It is interesting to note that, this is the first survey-based research in Afghanistan which evaluates students' conceptual understanding of Introductory Physics. The results of the study could be used as an important finding for future improvement of physics learning in Afghanistan. This study enables the first database to be established on Afghanistan university students' conceptual understanding of Introductory Physics.

The main objectives of this research are: to compare the level of Newtonian Mechanics conceptual understanding of Afghan and Malaysian university students, as well as to compare the average FCI scores of Afghan and Malaysian students with the obtained FCI results of students from other countries. Furthermore, this investigation can assist lecturers in evaluating the effectiveness of their teaching methods. It is hoped that, this research brings beneficial innovation to the instructional method; to improve physics teaching materials and, to improve the level of conceptual teaching and learning of Newtonian Mechanics.

METHODS

In this research, data were collected from a random sample of 90 (40 females and 50 males) national respondents from Kabul University and Kabul Education University in the centre of Afghanistan's capital, Kabul as well as from a random sample of 70 (56 females and only 14 males) national respondents from Universiti Teknologi MARA in Shah Alam, Malaysia. Lower number of Malaysian male student respondents in this study is a reflection of the current gender disparity in favour of female students in public universities in Malaysia (Tienxhi, 2017). A Pashto and a Malay translation of the latest updated version of the FCI were administered to the respondents from April 2017 until June 2018 of the academic year. All of the respondents have taken the Mechanics course prior to taking the FCI.

A Pashto translated and Malay translated versions of the 1995 FCI English version were selected in this study. Then, as permissions were granted to carry out the study, the FCI Pashto version was administered to the university physics students in the respective universities in April 2017 as well as the Malay version was administered to the university physics students in June 2017 and June 2018. All the answers were analysed and these results were then compared to those of other countries.

The analyses were done by using both Statistical Package for Social Science (SPSS) and Microsoft Excel. Independent samples t-test in SPSS version 24 was used to analyse the statistically significant difference in the mean FCI scores of Afghan and Malaysian university students. The t-test, a parametric test was used to check if the two mean values of scores are significantly different from each other. The p-value at the statistically significant level was set to .05 which is usually used in education researches.

RESULTS

Analysis and Evaluation of Results

The results in this study show that the average scores of the Afghan and Malaysian students were 26% with 11% standard deviation and 35% with 14% standard deviation respectively. The mean FCI score of the Malaysian students was 9% higher than that of the Afghan students. The results of the two-independent sample t-test shows that the 9% difference was statistically significant at 0.05 level where p value was 0.001 < 0.05. Table 1 shows the analysis obtained for both Afghan and Malaysian students.



Group	Gender	Ν	Mean Score %	Std. Dev.%	t	Df	Sig
	Male	50	26	11	650	88	510
Afghan Students	Female	40	25	10	.038		.312
	Total	90	26	11	.038		.001
	Male	14	40	22			
Malaysian Students	Female	56	33	11			
	Total	70	35	14			

Table 1.	Distribution	of the FCI s	cores according to	respondents gr	oup and gender

Table 2. shows that total from 90 of respondents 40 of them were females and 50 were males physics students from Afghan universities and from total 70 respondents 56 females and only 14 males physics students of Malaysian university. The descriptive statistics indicate that the average score achieved by Afghan male students was (M=26%, SD=11%) whereas female students obtained (M=25%, SD=10%). The findings indicate there is a difference between the mean scores of male and female university students. Thus, in order to examine wither, the difference is significant or not, an independent samples t-test was administrated and the results revealed that there was no statistically significant difference (t (88) = .658, p = .512) between the male and female mean FCI results of the Afghan student groups which is showed by the 0.05 significance level. Since the Malaysian male sample in this study was rather small comparison was not made against that of the female students.

Fig. 1 presents the percentages of the Afghan and the Malaysian students' FCI results along the six conceptual dimensions of Newtonian mechanics.





As can be seen from Fig. 1, the Malaysian students' performance is better than that of the Afghan students in all dimensions. The performance of Afghan and Malaysian students for each item in the FCI is presented in Fig. 2. It shows that the Malaysian students' performance is better than that of the Afghan students in all items on the FCI test except item number 5, 7, 8, 18, 19, 22, 23, 26 and 27.





Fig. 2 The Afghan and Malaysian students FCI results for each individual questions

Comparison of the Results of this Study with the FCI Results from the other Countries

The obtained FCI results from more than two decades in the field of Physics Education, are collected in many countries and in different languages like the USA (Bao, Cai, et al., 2009; Brewe et al., 2010; Hake, 1998; Hestenes, 1992; Hestenes et al., 1992; Lasry et al., 2011; Pollock et al., 2007; Said, 2015; Stone, 2006; Traxler et al., 2018; Zukoski, 1996), China (Bao, Cai, et al., 2009; Bao, Fang, et al., 2009), the UK (Bates et al., 2013), Russia (Bogdanov & Viiri, 1999), South Africa (Pare, 2007), Spain (Martin-Blas et al., 2010), Croatia (Planinic et al., 2010), Japan (Alinea & Naylor, 2016), Sweden (Fernandez et al., 2000), France (Rudolph et al., 2014), Canada (Milner-Bolotin et al., 2011), Malaysia (Abd Rahman et al., 2007; Kiong & Sulaiman, 2010; Nur & Shahrul, 2014; Sulaiman et al., 2006), Saudi Arabia (Bani-Salameh, 2017), India (Puri & Sarmah, 2014; Sharma & Sharma, 2007), Indonesia (Cahyadi, 2004; Syuhendri et al., 2014), Finland (Bogdanov & Viiri, 1999; Jauhiainen et al., 2001; Savinainen & Scott, 2002a), Thailand (Usawinchai, 2003), Turkey (Abdal Razzaq, 2014; Bayraktar, 2009), Laos (Luangrath et al., 2011) and the Philippines (Roleda, 2002). The results from this study and that of the mean FCI scores of students from the above-mentioned countries are summarized in Table 2.

As shown in Table 2, the FCI scores of the Afghan students are lower than most of the countries. Due to the four decades of war which had badly affected the human resources, laboratories and libraries in schools and universities in Afghanistan, these FCI results were expected.

Table 3. Comparison of the results of this study with	h that of students from other countries
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Name of Country	Mean FCI Score (%)	
Afghanistan	26	
South Africa	20 - 41	
Canada	25 - 55	
China	86 - 89	
Croatia	65	



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Finland	52 - 83	
France	49 - 60	
India	19 – 39	
Indonesia	18 - 47	
Japan	49 - 67	
Laos	18	
Malaysia	22 – 36 (35)	
Philippines	23 - 40	
Russia	48	
Saudi Arabia	27 - 38	
Spain	28 - 59	
Sweden	35 - 73	
Thailand	34	
Turkey	27 - 46	
UK	59 - 88	
USA	30 - 77	

In general, the results of this study showed that, both the Afghan and the Malaysian students have poor conceptual understanding of Newtonian physics which was less than the Newtonian entry threshold. Hestenes and Halloun (1995) suggested that the score of 60% can be considered as the Newtonian entry threshold for the development of Newtonian thinking and below 60%, the students have difficulties following physics courses. Poor conceptual understanding of Newtonian mechanics was also found in other countries around the world. A study, conducted in the Eastern Mediterranean University in Turkey (Abdal Razzaq, 2014) for a sample of 272 first and final year engineering students and 10 master students, found that the average FCI test score was only 28%, which is very similar to the scores of the Afghan students. In other recent study, the mean FCI score of university students from Saudi Arabia ranged from 27% to 38% (Bani-Salameh, 2017). In another study, performed on a sample of 318 freshmen at Srinakharinwirot University Thailand, the mean FCI score of 34% was reported which was very similar to the mean FCI scores of Malaysian students (Usawinchai, 2003). In this study, the researcher selected the Thai FCI version which included 26 test items (minus items number 8,9,10 and 11 which were related to ice hockey sport) of the 1995 version of the FCI. The high FCI Scores of freshmen college students from China was attributed to 5 years of continuous introductory algebra-based physics training from Grade 8 to Grade 12 undergone by every Chinese student. These physics topics based on the Chinese National Standards on K-12 Education emphasize conceptual understanding and skills needed to solve problems (Bao, L. et al., 2009).

Comparison of the Malaysian Students' Results of this Study with the Local FCI Results of prior studies

In this study, the Force Concept Inventory (FCI) Malay version test was administered to the Malaysian students in a university. The students were in their second semester and have taken the Newtonian mechanics in their first semester. The total number of Malaysian students participating in this study was seventy (N=70). These students were from the Physics Program offered at the School of Physics and Materials, Faculty of Applied Sciences, Universiti Teknologi MARA UiTM, in Shah Alam, Selangor. The mean score obtained was 35%. However, this result was slightly higher than the results of prior studies in Malaysia such as Universiti Teknologi MARA, Universiti Putra Malaysia and Universiti Kebangsaan Malaysia where the mean FCI scores are 22, 30, and 29 respectively (Sulaiman et al., 2006). In other studies, the mean scores of students from Universiti Teknologi Malaysia ranged from 26 to 30. (Abd Rahman et al., 2007; Nur & Shahrul, 2014) and from Universiti Teknologi Malaysia ranged from 24% to 28% (Kiong & Sulaiman, 2010). The detailed results of these studies using the Force Concept Inventory assessment instrument for Malaysian university students from 2010 to 2018 are summarized in Table 3 below.

Table 4. Comparisons of mean FCI scores of Malaysian national university students

University	Mean Score (%)	Year
UiTM	22	2006
UPM1	36	2006
UPM2	23	2006
UKM	29	2006



A	COMPARISON	OF	THE	FCI	SCORES	OF	AFGHAN	AND	MALAYSIAN	STUDENTS
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UTM	24 - 28	2010				
UPSI	30	2007				
UPSI	26	2014				
UiTM	35	2018				

UiTM-Universiti Teknologi MARA UKM-Universiti Kebangsaan Malaysia

UTM-Universiti Teknologi Malaysia

UPSI-Universiti Pendidikan Sultan Idris

UPSI-Universiti Pendidikan Sultan Idris

UPM-Universiti Putra Malaysia (formally known as Universiti Pertanian Malaysia)

DISCUSSION

The results of this investigation showed that students, especially the Afghan students, had many significant misconceptions in all parts of Newtonian concepts. These results confirmed most of the FCI results of previous studies which reported that, in general, students at all levels (school level, university, graduate and postgraduate) are still having difficulties in conceptual understanding of physics concepts and its basic principles (Abdal Razzaq, 2014; Bani-Salameh, 2017; Nur & Shahrul, 2014; Sharma & Sharma, 2007). Even though the results showed that Malaysian students are significantly better than the Afghan students, most of the test items were difficult for both Afghan and Malaysian students. There are several factors that may contribute to the low performance in the FCI scores of Afghan students compare to the FCI score of Malaysian students in this study and that of students from other countries. Firstly, it is due to the bad effect of war in the country. Hence there were insufficient qualified physics lecturers in Afghanistan. In general, according to the Afghan Ministry of Higher Education statistics, less than 5% of the lecturers are with PhD, about 30% with Masters and about 65% with only Bachelor degree teaching in public universities. Meanwhile, at school level, according to the Ministry of Education (2017) statistics, in 2015 only 10% of the teachers in Afghanistan's schools are graduates from universities with bachelor's degree where less than 1% are graduates in Physics (Babury & Hayward, 2014; Samady, 2013). The second factor is inadequate laboratories and trained staff as well as poor library facilities (Samady, 2013).

Munene (2014) found that learners whose lessons include regular performances of practical in the laboratory were better than those who were merely lectured in their classrooms. The science laboratory can be excellent surroundings for conceptual understanding (American Association of Physics Teachers, 1998). In addition, instructors play a significant role in the performances of their students. The last factor is the traditional physics teaching approach, where lecturers described and delivered the content with emphasis on mathematical equations and quantitative problem solving, giving less importance for conceptual understanding. Meanwhile, the results from many physics education researches show that traditional teaching approaches do not greatly promote students' conceptual understanding. At the same time, students' misconceptions are resistant to change by the traditional teaching approaches. A study by Abd Rahman and colleagues (2007) concluded that traditional instruction had little effect on changing the students' beliefs. In another study by Abdal Razzaq (2014), he stated that the traditional method of teaching Newtonian Mechanics had no effect on the Post FCI test' results. Hake (1998), Mazur (1999), Kim and Pak (2002), Bayraktar (2009) and Von Korff et al. (2016) found that traditional teaching of introductory physics classes does not significantly promote conceptual understanding in Newtonian mechanic's classes. Likewise, based on the findings of previously published data of the FCI results between 1995 and 2014 for over 30, 000 students have shown that traditional lecture-based teaching does not help students learn the fundamental concepts in Introductory Physics (Madsen et al., 2017; Von Korff et al., 2016).

In addition, educational environments affect students' learning outcomes and educators play an essential role in the academic success or failure of students. Thus physics laboratory exercises are also very important (Strayhorn, 2010). The laboratory work as an instructional method helps students master fundamental physics principles and concepts (American Association of Physics Teachers, 1998; Royuk, 2002). As for the mean FCI scores of the Malaysian physics students, even though they were statistically significantly higher than those of Afghan physics students, they were still in the category of low scores and did not reach the Newtonian entry threshold scores of 60%. It is hope that, the results of this research could be used as important findings for the future improvement of physics teaching and learning in Afghanistan and Malaysia especially at Universiti Teknologi MARA in Malaysia and in Afghanistan at Kabul University and at Kabul Education University.

CONCLUSION



In general, the results of the respondents in this study indicated weak performances in Introductory physics. In comparing the mean FCI score for two different groups of Afghan and Malaysian university physics students in two different versions showed that, the mean score of Malaysian students is significantly higher than that of Afghan students. The concept of Newtonian mechanics of Afghan female and male students did not differ significantly. Then the FCI results of this study were compared with that of other countries as shown in Table 2. This is an important first step towards improving the physics teaching and learning processes in Afghanistan. It is hoped that the results of this investigation will be useful for the respective universities to further develop physics teaching and learning in the country with special emphasis on conceptual understanding.

RECOMMENDATION

The following recommendations for further studies are offered:

- In an attempt to improve students' conceptual learning, extra efforts are required to encompass qualitative questions in exams and different homework (focus on conceptual homework material). Physics instructors should focus on students' conceptual understanding and plan teaching strategies in their lectures to address students' misunderstanding to make the concepts of physical phenomena and principles understandable. In addition, they should focus on experience and active learning and teaching techniques, as well as conceptual examples and a good problem-solving technique which encourage students to participate actively in their learning. These will facilitate better physics teaching and learning.
- The study should be extended to a larger group of male and female students from different schools and universities. This will enable comparison to be made between the performance of school and university students as well as female and male students. Furthermore, teaching approaches of physics in both schools and universities can be included, as well as students' misconceptions are to be investigated in further detail.
- Further studies on Malaysian students' performance in FCI is recommended to investigate the effect of test language, English FCI version and Malay FCI version, on the students' scores and the correlation to their physics learning. The improvement in students' physics learning in Malaysia could be used as guides for physics learning in Afghanistan.

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