THE LEVEL OF UNDERSTANDING OF STUDENTS AND TEACHERS IN THE CONCEPT OF FORCE AND MOTION

Mohammad Mubarrak Mohd Yusof, Siti Fairuz Dalim & Norezan Ibrahim
Faculty of Education
Universiti Teknologi MARA
Mubarak@salam.uitm.edu.my

Muhamad Firdaus Ramli
Faculty Art & Design
Universiti Teknologi MARA
azwhyec@gmail.com

ABSTRACT
This study investigates the level of understanding among students, the level of understanding among teachers and the common types of misconception among students and teachers in Force and Motion in 4 schools in Johor Bahru. This research uses a simple random sampling technique that involves 4 physics teachers and 116 students. Ujian Kefahaman Konsep Daya dan Gerakan was used to measure the level of understanding. Pilot study shows that the instrument has Alpha Cronbach reliability value of 0.638. The data was analyzed using SPSS program version 17.0. In overall, the data shows that the students fail to understand the Force and Motion concept with an average of 19.23% and standard deviation of 11.09. 60.4% of the students fail to understand the concept. The data also shows that the teachers’ level of understanding, on average is 21.88% and standard deviation of 10.83. However, 75% of the teachers have reached the level of poor understanding of Force and Motion concept and 25% of the teachers fail to understand the concept. There are 15 type of same misconception among the students and the teachers and 5 areas of misconception. These areas are Kinematic, Moving Force (Impetus) and Force effect, Action and Reaction, Force vector according to several influences and Gravity Force.

Field of Research: Misconception, Force and motion, Teacher and Student.

1. Introduction
Philosophy of National Education emphasizes on the continuous effort in developing the potential of a student in achieving the balance in terms of intellectual, spiritual, emotional and physical (Kementerian Pendidikan Malaysia, 2002). To achieve the national goal of education, teachers play an important role in developing the students’ potential. Teachers are directly involved in teaching and learning process in schools. Therefore, teachers are capable of influencing students in their respective fields (Jalaludin Othman, 1991). For physics subject, the teachers have to teach the concepts of physics to the students based on the syllabus that is provided. This is because the syllabus is the basic guide for the teachers to guide the students (Kementerian Pendidikan Malaysia, 2002). Therefore, the teachers’ understanding about the content and concepts in physics syllabus description is very important. There are several studies on the level of understanding of prospective teachers (Demirci, 2008), (Subahan Mohd Meerah, 1989; 1999) and students (Jamil Tarmizi, 2010). Other than that, most studies conducted on teachers’ mastery of concepts are usually confined to prospective teachers or education students only (Arzi & White, 2008), (Davis et al., 2006) and (Gess-Newsome, & Lederman, 1999). While, the in-service trainings for teachers are not sufficient enough in helping them to implement this curriculum (Subahan Mohd Meerah, 1999), plus, after several
years the level of in-service teachers' understanding was not yet tested or identified, it is important to identify level of understanding among teachers and students. This study is not only conducted to identify the level of understanding among teachers and students, the study is also carried out to examine the nature of the misconception of both teachers and students regarding the concepts of Force and Motion.

2. Research Method

The data obtained from the instrument were analyzed quantitatively. This research use the data quantitatively as a descriptive meant to explore the nature and similarity of both students' and teachers' misconceptions about the force and motion concepts inside four schools in Johor Bahru. The study involved experienced (and permanent) teachers population who teach physics in Johor Bahru district and all four form four classes who took physics and are taught by them (the experienced and permanent teachers). A total of four schools involved in the study. These schools are in the district of Johor Bahru but the school names are kept confidential in order to respect the participating teachers' demands. Each school was randomly selected and has only one teacher who meets the criteria (experience and permanent). A total of 4 teachers and 116 students were involved in this study.

The *Ujian Kefahaman Konsep Daya dan Gerakan* was used as the instrument in this study. This instrument is the result of modifications from the 'Force Concept Inventory'. Each question has five options ranging from A, B, C, D, and E. After modifications have been made to align with the to form four level of the physics subject without changing the original meaning of the items involved, the characteristics of misconceptions (Hestenes et al., 1992) have also been adjusted in order to achieve the kind of misconception faced by the respondents. Each choice of the answer describes the nature of the misconception of the respondents. For example in question 3, the options 'C' and 'E' describe that the respondents possess a misconception in the understanding Force Movement (Impetus) and force effects while option 'A' on the other hand describes that the respondents have a misconception in the Joined Force in Accordance to Several Influences part. Other than that, one of the answer choices can also describe that the respondents have two or three one misconceptions at a time. This instrument has also confirmed its suitability by a specialist physics teacher. This particular teacher made a suggestion to remove some items which are considered not in line with the current form four physics syllabus in Malaysia. Therefore, out of the 30 original questions only 16 questions are actually involved in testing the both teachers' and students' level of understanding and also their misconceptions. A pilot study was carried out in ‘Sekolah Menengah Kebangsaan Agama Johor Bahru’ in February 2012. A total of 30 form 5 students were involved. Cronbach Alpha test found out that the item reliability coefficient was as high as 0.638 and consistent with the pilot study done by (Sim, 2010) that attained 0.65 and (Yusof Hashim, 1994) attained 0.79 which involve almost the same instrument. After founded that the test item alpha reliability's value exceeds 0.6, the items were found to have reliability and can be used for the actual study (Gronlund, 1981). The mean is an arithmetic method that often used to measure the susceptibility of the data (Azizi Yahaya et al., 2007). Therefore, the mean value is used to determine the level of understanding of students and teachers in the Force and Motion. The mean range that determines the level of understanding is modified from the average achievement obtained from FCI Tests conducted in University Kebangsaan Malaysia, Universiti Teknologi Mara and Universiti Putra Malaysia, namely 24.5%. 24.5% then rounded to 25% in order to facilitate the data analysis (Zainal Abidin Sulaiman, 2006). Other than that, modifications to the level of understanding were made due to the fact that there are some questions that have been removed as they are not in line with the form four physic syllabuses. In this study, the usage and calculation of mean is used to examine the level of understanding of students and teachers as shown in Table 1.
Table 1: Students’ and Teachers’ Level of Understanding Analysis

<table>
<thead>
<tr>
<th>Score Range</th>
<th>Level of Understanding</th>
<th>Characteristics of the Level of Understanding</th>
</tr>
</thead>
<tbody>
<tr>
<td>x&lt; 25%</td>
<td>Fail</td>
<td>Failure to understand the concept of Force and Motion together with having many misconceptions</td>
</tr>
<tr>
<td>25 ≤ x &lt; 60%</td>
<td>Weak</td>
<td>Weak in understanding the concept of Force and Motion without too many misconceptions in the concept of Force and Motion</td>
</tr>
<tr>
<td>60% ≤ x</td>
<td>Mastery</td>
<td>Complete mastery in the concept of Force and Motion</td>
</tr>
</tbody>
</table>

3. Data Analysis

This section presents the results obtained from the study that has been conducted. Results that have been obtained from the data have been tailored to answer the research questions. Analysis was made based on the Ujian Kefahaman Konsep Daya dan Gerakan set gathered.

3.1 Students’ Understanding of Concept

The score for the Ujian Kefahaman Konsep Daya dan Gerakan is converted to a percentage and the mean mark of the students is analyzed. In overall, the students' mean was 19.23% with a standard deviation as high as 11.09. The students' mark are then categorized into failure to understand the concept of Force and Motion, weak in understanding the concept of Force and Motion, and mastering the concept of force and motion. Analysis found out that 60.4% of students fail to understand the concept of force and motion. A total of 39.4% is weak in understanding concepts of force and motion while no students actually managed to fully master the concept of Force and Motion.

3.2 Teachers’ Understanding of Concept

A total of four teachers are involved in this study. The researcher found out that the teachers’ average scores are at failure to master the concept of Force and Motion which is as high as 21.88% with a standard deviation of 10.83. Even though the teachers’ average scores are at failure to master the concept of Force and Motion is as high as 21.88%, however most teachers are at weak in mastering the concept of Force and Motion as 75% of them are in the weak level. This data shows 3 out of 4 teachers fail in mastering the concept of force and movement and one of the four teachers fail in the concept of force and motion. The analysis also found out that none of the teachers are able to fully master the Force and Motion concept.

3.3 Teachers’ Understanding of Concept

Having carefully analyzed all the answers for each respondent's selection, this section is divided into two parts which are the students and the teachers. The similarity in answer selection can be seen as caused by some parts of the misconception. These parts of misconception are actually portraying several types of misconceptions. There are 5 parts in a misconception and 15 misconceptions that are common among the students and the teachers. One of the common misconceptions among the students and the teachers is that they cannot distinguish between position and velocity, incapable of understanding the reaction of force movement due to impetus supplied by hit, cannot understand the loss of the original impetus, unable to understand the dissipation impetus, cannot understand the impetus build up, assuming that only the active agent (moving) exerts force, assuming force causes acceleration to go up to terminal velocity, assuming a large mass implies a large force,
assume the active agent (moving) produces The biggest force, unable to understand the joined force, assuming the last force is responsible in determining the motion, not capable of understanding the concept of (normal force) due to the touching surfaces, assuming that heavier objects fall faster, consider the gravitational pull increases as objects are falling and the last one is considering that gravitational force will only act upon the expiry of a movement. Table 2 shows the types of common misconceptions among the students and the teachers.

Table 2: Types of Common Misconceptions among the Students and the Teachers

<table>
<thead>
<tr>
<th>Parts of Misconception</th>
<th>Misconception</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kinematics</td>
<td>Unable to differentiate between position and velocity</td>
</tr>
<tr>
<td>Understanding of force (impetus) and force effect</td>
<td>Incapable of understanding the reaction due to impetus supplied by hit</td>
</tr>
<tr>
<td></td>
<td>Cannot understand the loss of the original impetus</td>
</tr>
<tr>
<td></td>
<td>Unable to understand the dissipation impetus</td>
</tr>
<tr>
<td></td>
<td>Cannot understand the impetus build up</td>
</tr>
<tr>
<td></td>
<td>Assuming that only the active agent (moving) exerts force</td>
</tr>
<tr>
<td>The relation between action and reaction</td>
<td>Assuming force causes acceleration to go up to terminal velocity</td>
</tr>
<tr>
<td>Forces vector in accordance to several influences</td>
<td>Assuming a large mass implies a large force</td>
</tr>
<tr>
<td></td>
<td>Assume the active agent (moving) produces The biggest force</td>
</tr>
<tr>
<td></td>
<td>Unable to understand the joined forces</td>
</tr>
<tr>
<td></td>
<td>Assuming the last force is responsible in determining the motion</td>
</tr>
<tr>
<td></td>
<td>Not capable of understanding the concept of (normal force) due to the touching surfaces</td>
</tr>
<tr>
<td>Gravitational pull</td>
<td>Assuming that heavier objects fall faster</td>
</tr>
<tr>
<td></td>
<td>Consider the gravitational pull increases as objects are falling</td>
</tr>
<tr>
<td></td>
<td>Considering that gravitational force will only act upon the expiry of a movement</td>
</tr>
</tbody>
</table>

Based on the analysis, it is found out that the overall level of students' understanding of the concepts of force and motion are in the failure stage. The result of this analysis has also found out that the level of teachers' understanding regarding the concept of force and motion is also in the failure stage. There are 15 types of common misconceptions among students and teachers around the four schools in Johor Bahru. 15 types of these misconceptions are divided into five parts. These 5 parts are kinematics, the Understanding of The Motion (Impetus) and force effects, the relation between Action and Reaction, the forces vector in accordance to several influences and lastly the gravitational pull. Figure 1 shows the overall conclusion.
4. CONCLUSION, DISCUSSION AND IMPLICATIONS

In principle, based on the students' and the teachers' low level of understanding in the data analysis, it reflects that there is a relationship between the students' misconceptions with the teachers' misconceptions. The similar misconceptions between the students and the teachers typically describe the nature of the students inheriting their misconceptions from their teacher (Burgoon et al., 2011). Therefore, based on the percentage of similar answer selection between the students and the teachers using the Ujian Kefahaman Konsep Daya dan Gerakan Instrument, the researcher has found out that there are 15 different types of common misconceptions between the students and the teachers. Among the similar misconceptions among the students and the teachers is that they are not able to distinguish between position and velocity. Another study (Yusof Hashim, 1994) has also found that 39.4% of students in Kulai have the same misconception. Studies done at the Universiti of Teknologi Malaysia (Sim, 2010) also found out that 66.16% of the education students at Universiti Teknologi Malaysia have the same misconception. The data obtain are also consistent with a study done by (Burgoon et al., 2011) and (Kikas, 2004). The study in Estonia (Kikas, 2004) was about the concepts of science among teachers. The researcher of Estonia study found out that 60% of the science teachers are capable of giving full explanation about the concept of velocity. 56.7% have a misconception of gravity force and inertia force. The study done by Burgoon et al. (2011) in quantitative and qualitative method found that a total of 62% of teachers said that gravitational force will increase if the object is released from a higher place. According to social learning theory of Bandura (1977) the habits and behaviour of an individual is built through imitation of the interaction between a teacher and a pupil. Consider the use of certain language is an imitation habit, as result of the interaction between a teacher and a student; According to the Bandura (1977), students' misconceptions might be the result of imitation of the teachers' misconceptions. This may be due to language factor which is the medium of interaction between teachers and students. As a contrast
the formation of a correct concept begins with language affinity and discrimination by recognizing the characteristics of a concept accurately (Gagné, 1968). Kikas (2004), with his study that focused more on the understanding of the concepts of science community expressed the importance of using the right language to start a discussion. The usage of common colloquial language for words such as Force and Energy, Weight and Mass are always confused and misunderstood. The failure of students and teachers alike in discriminating between the usage of words such as Force and Energy, Weight and Mass can lead to misconceptions. This may reflect the fact that language is one factor (Jasmeet Kaur, 2006) students and teachers misconceptions. In overall, this study found out that there are similarities in the misconceptions of teachers and students. However, the similarities are not yet capable of showing any proof of the relationship between students’ misconceptions and teachers’ misconceptions since there is no inferential statistic was done. Other studies such as Burgoon et al. (2011) and Kikas (2004) have focused only on the few types of misconceptions. This is due to the fact that the instrument they had used was different. Nonetheless, when looking at studies that had used more or less the same instrument just like the studies done by (Yusof Hashim, 1994) and (Sim, 2010), the researchers had found out that the 15 different types of misconceptions are consistent with their study. This means the instrument resulted from the modification of the Force Concept Inventory is useful in examining the misconceptions in terms of quantity (almost the same amount of percentage) because the study found out the same 15 misconceptions but in terms of, the finding out the quality of the relationship between misconceptions is limited.

The focus of the study is on students' understanding and their teachers regarding the force and motion concepts. Therefore, this study is hoped to help educators especially in helping to improve the performance of students in mastering the level of understanding, particularly for preparation when facing problems that requires higher level of knowledge and skill (Fatin Aliah Phang, 2005).

In order to enhance the study's findings, interviews may be conducted. Through the interviews, students will be able to give reasons for their responses and comprehensive data can be obtained to examine the relationship between students' misconceptions and teachers' misconceptions. Through this method, researchers can also improve the quality of the research by including the factor that teachers pass on their misconceptions.

The study can also be conducted on science teachers in secondary schools in other or larger areas. With greater involvement of teachers and students sample, an accurate inference analysis such as the Khi Square test can help in showing the relationship between students' and teachers' misconceptions. Researcher can also extend the study to help in implementing various measures such as reducing misconceptions between students and teachers thus indirectly improve the quality of the physics subject.

References


