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# The Level of B.Sc.Ed Students' Conceptual Understanding of Newtonian Physics

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**Abstract**
It is often taken for granted that students who are enrolled in a said Bachelor's Degree course in a university should have a much better understanding of the said subject then when they were in school. Studies conducted have shown that this may not necessarily be the case. They are often unable to apply the concepts that have been studied in the introductory Physics course to the task of solving related problems. The purpose of this study was to ascertain the level of Newtonian Physics conceptual understanding of university students enrolled in Science Education courses in order to investigate their preparedness in becoming future Physics teachers. This survey-based study involved a sample of 200 third-year B.Sc.Ed students from three universities in Malaysia. Data collected from the Test of Conceptual Understanding of Newtonian Physics was analyzed descriptively and inferentially to determine the level of the students' Newtonian Physics conceptual understanding. The findings confirmed that generally, undergraduates' students are still having problems to conceptually understand physics concepts taught at them.
**Keywords**: Conceptual understanding of Newtonian Physics, B.Sc. Ed. Students, Physics Education

## Introduction

Conceptual understanding of Newtonian Physics in its most basic form means understanding the principles of science, especially the concepts of Newtonian Laws used to explain and predict observations of the natural world and knowing how to apply this understanding efficiently in the design and execution of scientific investigations and in practical reasoning (NAEP, 2005). Girad and Wong (2002) state that conceptual understanding requires both knowledge of and the ability to use scientific concepts to develop mental models about the way the world operates in accordance with a current scientific theory. It is important to ensure the mastery of science concepts among students (NAEP, 2005). Furthermore, it develops a student's ability to apply facts and events learned from science instruction and from personal experiences with the natural environment, to use scientific concepts, principles, laws, and theories that scientists use to explain and predict observations from the natural world.

Most educators agree that science teaching and learning should move away from a system that promotes science primarily as recall of factual information and rote computation to one which emphasizes conceptual understanding and logical process skills. However, this goal has not been easily attainable. Literature reviews show that the problems of conceptual understanding are widespread among students. Studies have found that most students still have naïve ideas about the concepts of Newtonian Physics. The high school and undergraduates students are generally found to have an understanding that is not scientifically accepted according to their world, known also as the *alternative conception* (Trowbridge, & McDermott, 1987, 1993; Halloun, & Hestenes, 1985; Van Heuvelen, 1991; McDermott, 1993). Research findings also concluded that even if students have been exposed to Newtonian Physics from the early stages of their schooling years, they are still yet unable to master the knowledge of Newtonian Physics (Trowbridge, & McDermott, 1980, 1981; Halloun, & Hestenes, 1985; Van Heuvelen, 1991; McDermott, 1993; Brandsford, & Schwartz, 1999). Students encounter difficulty when asked to apply a concept or line of reasoning to a situation different from which it was learned (Boudreaux, 2004).

This particular situation also occurs in Malaysian schools. Majority research (Khalijah, Subahan, & Khyasudeeen, 1991; Lee, Ahmad Nurulazam, & Seth Sulaiman, 1992; Yusof, 1994; Lilia, 1998; Lilia, Abd. Razak, Abd. Rasyid, & Subahan, 2001) done have shown that most students in introductory physics courses are unable to conceptually understand the basic principles of Newtonian Physics. Yusof (1994) in his study involving 175 form five students from Kulai and Kota Tinggi, Johor, had found that approximately 99 percent of the respondents are unable to answer the Test of Hestenes Concept. This test (Halloun, & Hestenes, 1985a; Halloun, & Hestenes, 1985b) was specifically formulated to assess the conceptual understanding of Newtonian Physics among students. The sample, however, is found to have not had the desired understanding. This result confirms the findings of the research conducted in 1992 by Lee, Ahmad Nurulazam and Seth Sulaiman on 485 students in ten secondary schools in the state of Perlis, Kedah and Penang. The study shows that more than 50 percent of the respondents involved are facing problems related to the conceptual understanding of physics.

Similar results were also obtained in a study conducted by Khalijah, Subahan and Khyasudeeen (1991) on students of higher learning institutions, including teacher trainees. The sample tested their understanding of the force and movement's concept It was found that students at this level also unable to grasps a better conceptual understanding of Newtonian Physics, even after being exposed to more than four years of the related course. A similarly consistent result was also obtained from studies conducted by Lilia (1998) and Lilia et al., (2001). Using a sample of science teacher trainees in one of the higher learning institutions in Malaysia, results obtained concluded that nearly 50 percent of the respondents involved could not display their conceptual understanding of physics concepts proposed. All these findings indirectly indicate that, generally, students genuinely do have problems to conceptually understand concepts taught in the subject of Physics. And, even though some may get high scores in tests of quantitative physics, it is not a guarantee for them to have a better conceptual understanding of Physics (Kim, & Pak, 2001).

## Rational of the Research

In order to prepare a qualified and skilled science teacher, the extent of the level of conceptual understanding of Newtonian Physics among Bachelor of Science Education (B.Sc.Ed) students must be examined to give us an overview of their knowledge of this subject. It is often taken for granted that students who are enrolled in a said Bachelor's Degree course in a university should have a much better understanding of the said subject then those were in school. There is little empirical data available about the comparison between the level of conceptual understanding of Newtonian Physics among B.Sc.Ed students with school students.

## Research Objectives

The purpose of this study was to ascertain the level of Newtonian Physics conceptual understanding of university students enrolled in Science Education courses in order to investigate their preparedness in becoming future Physics teachers. In particular, the objectives of this study were to seek the answers for the following questions:

1) What is the level of conceptual understanding of Newtonian Physics of B.Sc.Ed students compared to form four science students?
2) Is there a significant difference between the level of conceptual understanding of Newtonian Physics of B.Sc.Ed students compared to form four science students?

## Research Methodology

Survey research method has been applied in order to collect the data required. An instrument known as the Test of Conceptual Understanding of Newtonian Physics has been administered to a group of 200 third-year B.Sc.Ed students in three higher learning institutions in Malaysia and 200 form four science students in three science secondary schools in Malaysia. The test was formulated based on an adaptation of the items obtained from Force Concept Inventory (***Hestenes***, Wells, & Swackhamer, 1992), Mechanic Baseline Test (Hestenes & Wells, 1992), ConcepTests (Mazur, 1997) and relevant materials to fulfill the objectives of the research. Questions presented are based on concepts such as the students have learned during the secondary school level. Generally, students are required to answer 28 questions related to the conceptual understanding of basic concepts of Newtonian Physics. (The reliability of this instrument had been tested in a pilot test conducted on a different sample prior to the intervention).

## Ethics and consent

All study procedures were approved by the relevant authorities (the highest authority of the educational institutions involved), as independent research. The participants were informed of all of the essential elements of informed consent. Only the participants who gave informed consent to participate in this study were included. They were also ensured that their anonymity would be protected throughout the study.

## Limitations

This study is intended to answer research questions stated and is limited to only the specified sample study. This study also does not take into account demographic factors of the involved samples. Generalization results of this study only refer to the Test of Conceptual Understanding of Newtonian Physics administered to the research sample.

**Statistical methods**

Data obtained from the test conducted were then analyzed descriptively and inferentially to seek the answer to the questions raised. The mean score for each question was calculated for each group of the sample. Independent samples t-test was then performed to analyzed the differences in the level of conceptual understanding of Newtonian Physics between the groups, with p values less than 0.05 is considered to be statistically significant. All statistical analyses were performed using SPSS (Statistical Package for the Social Sciences) version 15.0.

**Findings**

Descriptive analysis

Result obtained from the Test of Conceptual Understanding of Newtonian Physics among students show that there is a difference in the ability of B.Sc.Ed students and form four science students in answering correctly the paper. It is found that out of 28 questions related to the concept of Newtonian Physics proposed, it is found that 13 of them received a good response from B.Sc.Ed students and 15 other questions got a good response from the form four science students. This imply the inconsistency between the knowledge of Newtonian Physics of form four science students and the B.Sc.Ed students.

Analysis shows that for B.Sc.Ed students, the most difficult questions (less than 20 students answered correctly) is questions related to the concept of ball movement on flat surfaces, whereas for form four science students, the most difficult question is related to the concept of conservation of energy and momentum. In relation to that, for B.Sc.Ed students, the questions that most of them get the correct answer (more than 80 students answered correctly) are questions related to the concept of inertia, momentum, velocity-time graph, balanced force and impulse. While for form four science students the similar question is only focused to the concept of inertia. This results show that in general, compared to form four science students, B.Sc.Ed students are found to have grasped more concepts on Newtonian Physics.

Inferential analysis

Results obtained for the inferential analysis of the data analysis are shown in Table 1 and 2 below.

Table 1 Comparison of mean scores, standard error and standard deviation for the Test of Conceptual Understanding of Newtonian Physics between B.Sc.Ed students and form four science students

| Group | N | Mean score | Standard error | Standard deviation |
|---|---|---|---|---|
| B.Sc.Ed. students | 200 | 15.20 | 4.23 | 0.43 |
| Form four science students | 200 | 15.40 | 4.67 | 0.47 |

Table 2 Independent samples t-test for the Test of Conceptual Understanding of Newtonian Physics between B.Sc.Ed students and form four science students

| Levene Test | | Independent t-test | | | | | | |
|---|---|---|---|---|---|---|---|---|
| F | Sig. | T | df | Sig (two-tailed) | Mean different | Standard deviation different | 95 % Confidence difference | |
| | | | | | | | lower | upper |
| 3.727 | 0.055 | -.309 | 190 | .757 | - .197 | .640 | -1.460 | 1.064 |

Significance levels, p = 0.05

Based on Table 1, it is found that B.Sc.Ed students have obtained the mean score of 15.20 in the Test of Conceptual Understanding of Newtonian Physics administered. This finding implies that in general, B.Sc.Ed students posses a moderate level of conceptual understanding of Newtonian Physics. The result shows that the score gained is similar to the mean score of form four science students, who obtained 15.40. Therefore, results of the independent samples t-tests analysis conducted has shown that there is no significant difference between the mean score of the Test of Conceptual Understanding of Newtonian Physics of B.Sc.Ed students (M = 15:20, SL = 4.23) and form four science students (M = 15:40, SL = 4.67) with t value is -0.309 and p = 0.757, p> 0.05. (Table 2).

**Discussion**

Based on the Test of Conceptual Understanding of Newtonian Physics administered, it is found that there is a slight different in terms of conceptual understanding level between B.Sc.Ed.students and form four science students. B.Sc.Ed students are found to be skilled in resolving problems related to the concepts of inertia, momentum, velocity-time graph, balanced force and impulse while form four science students are found to be skilled in solving the inertia concept. This result shows that B.Sc.Ed students are better in solving a lot more physics concepts compared to form four science students.

However, in terms of the level of conceptual understanding of Newtonian Physics, research findings indicate that B.Sc.Ed students only have the similar level as form four science students. There is no significant difference between the mean score of conceptual understanding of Newtonian Physics of B.Sc.Ed students (M = 15:20, SL = 4.23) and form four science students (M = 15:40, SL = 4.67) with t value is p = - 0.309 and 0.757, p> 0.05.

Results obtained confirm previous research findings which stated that, generally, students are still having problems to conceptually understand physics concepts taught at them (Trowbridge, & McDermott, 1980, 1981; Halloun, & Hestenes, 1985; Van Heuvelen, 1991; McDermott, 1993, Khalijah et al., 1991; Lee et al., 1992; Lilia, 1998; Lilia et al., 2001).

This does not only occur among the form four science students, who are still in the initial process of leaning physics, but also among higher learning institutions' students, who have been exposed to the related concept for a number of years. Logically, B.Sc.Ed students should show a better performance compared to the form four science students as it is assumed that they would have a better physics knowledge and understanding while furthering their education. However, it is found that this is still not proven.

The results show that although B.Sc.Ed students are exposed to the physics concept more specifically while at the university level, their conceptual understanding are still not effectively well developed. This is maybe due to the fact that there is a lesser emphasis on basic concepts at the university level as students are generally considered to possess adequate knowledge understanding of the basic concepts in order to be accepted to a higher learning institution. However, it is obvious that the assumption is not at par with the findings obtained from this study, which concluded that generally, B.Sc.Ed students are still having problems to conceptually understand the concepts of Newtonian Physics. Compared to form four science students, it is found that the level of conceptual understanding of Newtonian Physics of B.Sc.Ed students does not show any further improvement.

As a result, it can be stated that the level of education does not guaranteed for a better physics conceptual understanding among students. Hence, the emphasizing of concept mastery should be considered from the early stages of Physics learning process to ensure a better performance among students, in assuring them to understand physics meaningfully as well as able to apply the knowledge in their lives. This is crucial to prevent any further related issues regarding conceptual understanding problems due to at the tertiary level, it is found that this aspect is no longer a major consideration as students are considered to grasps this kind of understanding in their previous learning.

**Conclusion**

Results of the study indicated that B.Sc.Ed students generally have the level of Newtonian Physics conceptual understanding equivalent to that of form four science students. There is no significant difference between the mean score of B.Sc.Ed. students and form four science students in the Test of Conceptual Understanding of Newtonian Physics administered. Therefore, it can be concluded that university students, more often than not, have similar conceptual difficulties to those that are currently in secondary schools.

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