PEER LEADER'S CONCEPTUAL KNOWLEDGE OF INTRODUCTORY PHYSICS AND ITS IMPLICATIONS

Jennifer Johnston[1,a)], George McClelland[1]

[1]*Department of Physics, University of Limerick, Ireland*

1 INTRODUCTION

During the past two decades, physics education research has shown the difficulties students have in learning physics. For many researchers the primary emphasis has been on conceptual understanding of physics, particularly in the area of mechanics. The literature reports that, regardless of the students' background or age, basic preconceptions or misconceptions about physics exist which affect further learning and achievement [1,2,3]. The persistence of these misconceptions suggests that they are not easily overcome. The link between physics instruction and persisting physics misconceptions is the key to further developments in physics education research [2].

Research has shown that there is often little change in a students' conceptual understanding before and after formal instruction [4]. Many students' achievement and conceptual knowledge has been assessed using physics conceptual tests that have been tested and applied [1]. It is however difficult to quantify precisely a change in conceptual understanding through these tests alone.

Various innovative teaching approaches are increasingly used within university courses to enhance student learning and the students' learning experience. Such innovations include peer, collaborative or cooperative learning, in particular small group activities. The innovative teaching approach reported on here is Peer Learning utilising Peer Leaders in the University of Limerick.

The main purpose of this paper is to investigate Peer Leaders' conceptual knowledge and structure of thought in introductory university physics and its implications for their effectiveness as Peer Leaders.

1.1 Background

Peer Learning typically involves students working in cooperative groups with a teacher as facilitator. Peer teaching involves students learning from and with each other in ways, which are mutually beneficial [5]. The peer teacher serves as a role model having previous experience of the course. These peer teachers are called '*Peer Leaders*' and include undergraduate teaching assistants, and tutors [6]. Peer Learning groups are structured and managed to maximise the active and appropriate participation of all students in the group [7].

The effectiveness of participation in this programme is established through an examination of their conceptual understanding. The author developed a module specific conceptual understanding test and a questionnaire to examine any changes that may have occurred. The selected first year undergraduate physics module,

[a)] Corresponding author's e-mail: jennifer.johnston@ul.ie

Mechanics and Heat (PH4101), defined the context of the investigation. Basic mechanics, dynamics, gravitation, and mechanical, fluid and thermal properties of matter were studied in a 15-week semester, (Sept 06 – Dec '06). The class was comprised of students from diverse backgrounds (N = 153), including biological and physical science teaching (N = 81), sports science (N = 64), and biomedical and advanced materials (N = 8). Each student was timetabled to attend one tutorial (50 minutes) a week.

The students experienced the Peer Learning method in every tutorial. Peer (undergraduate) Leaders guided the activities of small groups of students in the weekly tutorials. The students worked through challenging problems that are designed to be solved cooperatively. The Peer Leaders were trained to ensure that the students were actively and productively engaged with the material and with each other.

1.2 Research Questions

- Do the Peer Leaders experience a change in conceptual knowledge in their physics understanding?
- What are the effects of the Peer Teaching on the Peer Leaders?
- Does the implementation of the Peer Learning method enhance Peer Leaders' learning?

2 METHODOLOGY

2.1 Sample

The Peer Leaders selected for this programme were third year undergraduate science teachers (N = 11) who had taken the module (PH4101) in their first year. The research participants (Peer Leaders) were recruited on a volunteer basis, through a recruitment flyer emailed to the class and through cooperation and discussions with their course leader. There were five tutorials a week, with two Peer Leaders per tutorial.

The Peer Leaders who volunteered were not experts in the field nor were they expected to be. The only requirement was that they had previously studied the course. The Peer Leaders were randomly assigned to the tutorial slots due to timetable constraints. The author attended all the tutorials to provide guidance and support to the Peer Leaders.

2.2 Instrument for data collection

The conceptual test was administered as a pre- and post-test to the Peer Leaders. The value of becoming a Peer Leader in relation to the development of their teaching skills and the change in conceptual knowledge is analysed.

2.3 Module Specific Conceptual Understanding Test

A module specific conceptual understanding test was developed to analyse the Peer Leaders' conceptual understanding of Mechanics and Heat (PH4101). It contained three sections.

- Section 1: Open ended everyday occurrences of physics phenomena.

- Section 2: Multiple-choice (FCI) Force Concept Inventory [1]; students were asked to reason out choices their selection.
- Section 3: Mathematical manipulation of physics problems.

Section 1A and 1B contained 22 questions, which probed, from different perspectives, the cognitive link Peer Leaders possess of basic mechanics and heat (i.e. forces of friction, exerted force). All questions were qualitative but contained different levels of conceptual difficulty. The subjects received the questions in a random sequence.

The following are sample questions from section 1A and 1B consecutively,

> *Q2. Start a ball rolling down a bowling alley and you'll find it moves slightly slower with time. Why?*
>
> *Q20. When touching an object, the sensation of hot and cold is a measure of object's overall temperature. True or false, explain you answer.*

Students were asked to respond to six FCI questions (numbers 6, 8, 11, 13, 18, 21, 28 in the numbering system of the original authors) in section 2. The questions selected from the original FCI were picked at random. The FCI test is widely used to gauge the initial mechanics knowledge state of undergraduate students, as well as to quantify the effect of instruction on the knowledge state of the students [8]. In addition to answering the multiple-choice questions the Peer Leaders were instructed to reason out their choice of answer. The outcome of the pre-test/post-test analysis indicates if any changes have occurred in the students' common-sense understanding of physics. Section 3 investigated their mathematical reasoning in physics problems such as interpretation of a graph. The test took approximately 40 minutes to complete.

Questionnaires The author administered the questionnaires during the first and final Peer Leader meetings. The pre questionnaire contained ranking questions on what benefits the Peer Leaders thought they might acquire from participating in the programme. They had to rate their confidence in different statement relating to teaching physics and they also had to rank the same statements after they had completed the programme stating whether they had experienced any of the benefits expected.

3 RESULTS

3.1 Results

The module specific conceptual understanding tests were analysed both qualitatively and quantitatively. The total test score achieved by the Peer Leaders, and the individual sections are presented.

There was a significant difference ($P < 0.05$) between pre and post test ($N = 11$) total test scores as seen in Table 1 below.

Table 1 Total conceptual understanding test scores.

Test	Scores
Pre test mean	32.77%
Post test mean	45.39%
Average % gain from pre to post	12.63%

3.2 Conceptual test section breakdown

The following reports on the finding of the individual sections and also states the number of Peer Leaders who completed each section. As can be seen from the table 2 – 5 below the response rate decreased, this was due mainly to time constraints. Table 2 shows results form section 1A, there was no significant difference ($P > 0.05$) between pre and post test ($N = 11$), but there was a slight increase in means.

Table 2 Section 1A conceptual understanding test scores.

Test	Scores
Pre test mean	36.97 %
Post test mean	45.45 %
Average % gain from pre to post	8.48 %

Table 3 shows there was no significant difference ($P > 0.05$) between pre and post-test ($N = 10$) on the heat section, again a slight increase in the overall mean is shown.

Table 3 Section 1B Heat conceptual understanding test scores.

Test	Scores
Pre test mean	38%
Post test mean	56.67%
Average % gain from pre to post	18.67%

There was no significant difference ($P > 0.05$) between pre and post-test ($N = 8$) of the FCI section, shown in table 4. This section saw the least improvement or change in scores from pre to post-test. Scores pre and post were below average, and students had difficulty in reasoning out their answers clearly. We note that the results are really low and cannot be compared to the general results of the whole original FCI test. The choice of questions and the reasoning required possibly added to this factor.

Table 4 Section 2 FCI Conceptual Understanding test scores.

Test	Scores
Pre test mean	21.5 %
Post test mean	23.08 %
Average % gain from pre to post	1.92 %

Table 5 illustrates the mathematical reasoning scores. The Peer Leaders pre results were above average to begin with, demonstrating a high level of ability with the mathematical manipulation. However, no significant difference ($P > 0.05$) between pre and post-test ($N = 6$) was reported.

Table 5 Section 3 Mathematical Conceptual Understanding test scores.

Test	Scores
Pre test mean	56.12 %
Post test mean	60.36 %
Average % gain from pre to post	4.23 %

3.3 Qualitative analysis of concept tests

The qualitative analysis reports on a more in-depth examination of what the Peer Leaders wrote. The open-ended sections of the test were coded using the following criteria; a question was corrected on the bases of whether the student reported the answer in Newtonian, Pre-Newtonian or not classified into either. The following is a sample student answer,

> *Pre test: 'As it rolls down the energy you used to roll it is being lost and it begins to decelerate.' (Pre-Newtonian).*
>
> *Post test: 'Friction between the ground and the ball will slow down the ball as it moves' (Newtonian).*

3.4 Questionnaire Analysis

All the Peer Leaders ($N = 11$) stated that becoming a Peer Leader improved their physics knowledge. They reported that they enjoyed being a Peer Leader and that they had a positive experience. They felt that the students also benefited from the programme. However, they felt that preparation time took longer than expected but that they would take part in the programme again. In the confidence ranking question, the Peer Leaders reported that they were not confident or were least confident in their physics knowledge where as post results reported an increase in their physics knowledge. Confident in their teaching skills saw significant increases too. Benefits such as improved physics knowledge, teaching skills, leadership skills are thought to occur from participation as a Peer Leader. The Peer Leaders' stated that they felt that the benefits did occur. They reported that an improvement in their physics knowledge has occurred or definitely occurred. They

also felt the other areas had benefited especially their teaching skills and leadership skills.

4 CONCLUSIONS

Conceptual understanding tests illustrated that there was a significant difference ($P < 0.05$) in the Peer Leaders' total test scores. Preliminary results of the qualitative data indicate a change in conceptual understanding. The Peer Leaders felt that their physics knowledge had increased. They reported an increase in confidence in their teaching and physics skills. They felt they benefited from the experience. Initial investigations suggest that the Peer Leaders did experience a change in their conceptual understanding of physics. Preliminary findings suggest that the Peer Learning method employed is effective in providing beneficial teaching and learning opportunities to Peer Leaders. This study presents initial investigations in the field and research is ongoing.

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