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Students' responses to a modification of the teaching approach in an introductory physics course

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Abstract: *Traditional teaching methods are still preferred by some students, despite being reported to contribute to problems in student understanding introductory physics. Having been taught passively for a long time, students are usually resistant to changes in teaching methods. Students' attitudes to change are important in their response to improving their comprehension of physics. This paper investigates students' responses to elements of a modified teaching approach which consists of assessed group work in tutorials, WebCT reading quizzes, peer discussion during in-class demonstrations and pre-lecture downloaded hand-outs. The students were expected to engage actively in their learning, inside and outside the classroom, with activities such as web-based quizzes and team involvement that they may encounter in their further employment. The students showed more concern with tasks which were both new and assessed. Some student comments regarding activities perceived to be not helpful indicated a problem of time management outside the class. In general, however, the students were quite adaptive to the change in teaching approach. This adaptability can be considered as a promising indication in helping the students to learn better.*

Keywords: *Student response; teaching reform; introductory physics.*

Introduction

There is a growing body of literature (e.g., Halloun & Hestenes, 1985; Hestenes, Wells, & Swackhamer, 1992; Kim & Pak, 2002) indicating that traditional teaching methods contribute to unsatisfactory student understanding in introductory physics courses. Traditionally, a lecturer presents the material out of the textbook, does the problem solving examples and occasionally performs demonstrations. Students listen to the presentation, take notes, but rarely ask questions or give comments. In the recitation (tutorial) sessions, students just copy the solution presented by teaching assistants into their notebooks. Despite the students' demonstrated skill in solving textbook-like problems, their underlying conceptions do not seem to be affected by the instruction they receive in the class. This "naïve conception" (McClosky, 1983) or "misconception" (Halloun & Hestenes, 1985) has been recorded in almost all areas in physics, particularly in mechanics, since the 1980s. Unfortunately many lecturers, as well as the students, are rarely aware of this problem, since both parties are so accustomed to the traditional teaching situation.

In the last two decades, there has been an accumulation of research, which attempts to solve this problem by suggesting a number of alternative teaching approaches (see for example, a review by Hake, 1998a). Most of the results are encouraging in terms of the expected improvement of student understanding. However, Ramsden (2003) noted that student learning was affected by a number of factors such that the "context of learning" may be different from one student to another, from one classroom to another and from one country to another. As most findings in the area of physics education research (Hake, 1998b; McDermott, 2001) originate in the United States institutions, we may want to be reasonably cautious in adopting certain approaches to improve our local learning environment.

The aim of this paper is to describe a modification of the teaching approach in an introductory physics course in a New Zealand university. The modification took the form of assessed group work in tutorials, WebCT reading quizzes, peer discussion during in-class demonstrations and pre-lecture downloaded hand-outs. In developing a holistic approach, the approach was expected to guide students on managing time inside and outside class, adapting to changes, and seeing the relationship between purpose, activity and result. The particular focus of this paper is the students' reactions to the modification, which is partly inspired by the findings in the American institutions. Several studies (Prosser & Millar, 1989; Coleman, Holcomb, & Rigden, 1998) have pointed out that student attitude plays an important role in building the desired conceptual understanding of the subject. The research question is: what are the students' reactions to several elements of the modified teaching approach? The answer to this question will give insight to students' expectations and to help the refinement of the modifications of the teaching method in the future.

Literature review

A number of researchers have acknowledged the shortcomings of traditional lectures. Based on the observation of student understanding in numerous areas of introductory physics, McDermott (2001) put forward a generalization that "teaching by telling is an ineffective mode of instruction for most students" (p. 1133). A good lecturer may present physics in an interesting way, but students do not always know how to learn it appropriately (Hestenes, 1998). This fact may not be realized by both the lecturer and the students as they have been comfortable with this style of teaching.

Redish, Saul and Steinberg (1998) recognized the first year of college as a crucial point to make the change. They also suggested the importance of assessing students' expectations in order to facilitate the desired transformation in their attitude towards physics. Their advice to physics educators is to change the focus from "What are we teaching and how can we deliver it" to "What are the students learning and how do we make sense of what they do?" (Redish & Steinberg, 1999, p. 24). In other words, we need to learn more about our students' opinions of their learning.

Most reports on the reforms of the teaching method (see the researches reviewed in Hake, 1998b) present the improvement in student understanding of particular concepts. There are only a few others (e.g., Sharma, Millar, & Seth, 1999; Leslie-Pelecky, 2000; Steinberg & Donnelly, 2002; Scherr, 2003) discussing student attitudes. Not all responses from students, however, are encouraging. The exposure to any form of physics instruction increases the unfavorable attitudes of learning physics (Redish, Saul, & Steinberg, 1998) and decreases student interest (Coleman, Holcomb, & Rigden, 1998). A significant number of students still prefer to be taught in the traditional style even after they attended an "active-learning" program of an introductory physics course (Mottmann, 1999). Despite its successful and wide implementation, Peer Instruction (Mazur, 1997) only slightly improves the student attitudes (Crouch & Mazur, 2001). One of the challenges faced by instructors using Peer Instruction is the students' resistance to actively engage in a discussion with their peers (Fagen, Crouch, &

Mazur, 2002). This may demonstrate the notion that some students are not comfortable with a new approach in the classroom.

Elby (1999) speculated that a long history of successfully adopting rote learning habits contributes to the student belief that focusing on physics formulas and problem solving algorithms is essential to obtaining good grades in an exam. Students usually vote lectures and problem assignments as the most useful activities for their learning (Cahyadi, 2003; Coleman, Holcomb, & Rigden, 1998). The situation in a typical lecture hall may influence the students' ideas of learning physics. Fritschner (2000) identified the lecturers' expectation for the students to turn up and pay attention in class, while some students were discouraged to participate in the class by their perceived behaviour of the lecturers.

The student perceptions described above should not be viewed as discouraging in our endeavor to improve the quality of teaching (and learning) in our course. As Crouch and Mazur (2001) acknowledged, it takes time for students to be comfortable with a new instructional approach before any change towards a different and better approach can be realized. Listening to the students during this "period of adjustment" is indeed important in refining the approach so that it can help them to learn better.

The modification of the PHYS112 course and students' responses

Entry to part B of the physics course of Engineering Intermediate and to physics at the University of Canterbury requires a reasonable prior knowledge which is measured by the minimum of 58% average in each of Bursary (final exam of high school) physics and mathematics with calculus. Those without this knowledge are required to pass part A (PHYS111: Introduction of Physics to Engineering and Sciences) course in semester 1 and take part B (PHYS112: Waves, Thermodynamics and Materials) in semester 2. At the time when this study was conducted, the composition of the PHYS112 class was 70% graduated from PHYS111 and 12% failed from part B (PHYS113: Waves, Thermodynamics and Materials) in semester 1. In other words, the class (N = 198) consisted mostly of students with a weak ability in physics and some others (18%) choosing PHYS112 for timetable reasons over PHYS113.

The instruction and activity conducted in PHYS112 and the other courses mentioned above had been of traditional style as described previously. Inspired by the movement in physics education research, it was decided to make some modification to the PHYS112 course. The new aspects introduced as the modification are: assessed group work in tutorial, WebCT reading quizzes, peer discussion during in-class demonstration and pre-lecture downloaded hand-out. The details of these and students' reactions to each of the activities will be discussed below.

At the end of the semester, students were asked to fill in a course survey developed by Survey and Testing Unit of the University of Canterbury. A total of 107 students (54% of the class) completed the survey. There were 14 statements to be rated using the scale of 1 (*strongly disagree*) to 5 (*strongly agree*). In addition to those statements, there were two open-ended questions for students to give comments. These comments may give insight into what they thought about several elements of the modification. The wording of the questions is:

- Which aspects of this course were most helpful in your learning?
- How could this course be changed to assist your learning?

The number of students responding to the questions was significant: 77 students or 72% of all those completing the survey. The students could be assumed to put forward their significant concern when they took the trouble of writing instead of just circling the numbers indicating their rating. It should be noted that the number of similar comments does not represent the proportion of students having some particular opinions. It is, however, informative to observe the proportion of some contradictory responses on a certain element.

Assessed group work in the tutorial

The group work was initiated in the PHYS111 class in the previous semester where students were given worksheets containing qualitative problems to discuss for non-assessed tutorial work. Qualitative questions are claimed to be useful in assisting students to learn (McDermott, 2001). The small group discussion on the conceptual and quantitative problems was continued to be encouraged in the tutorials of PHYS112, this time the student work was graded. Students were explicitly told that they needed to have a strong conceptual comprehension as well as the skill in problem solving to perform well in the exam. This was intended to establish the alignment between objective, activity and assessment (Biggs, 1999).

Students rated 3.1 on average the statement that the tutorials/seminars/student-led discussions were a valuable aid to their learning. The number of positive and negative comments on the tutorials was equal: there were 20 for each. The appreciative comments suggested that tutorials were helpful because the answers were provided, the homework and tutorial work were marked, and "the problems were well suited for exam prep questions". The most complaints (10 students) indicated that the problems were perceived to be too hard, too many or too time consuming. Other complaints were about the tutor, the tutorial schedule, the "compulsory" nature of the tutorial and the weighting of the work. There were only 1 or 2 individuals mentioning each of these aspects.

The quantity of work and type of activity may pose a challenge for students if they are not used to them. There was a significant increase in the number of assessed quantitative problems that the students had to do every week, from one problem in the previous course to 5-6 problems in the present course. The complaints that the problems were too hard, too many or too time consuming might indicate the impact of the change on some students.

WebCT reading quizzes

To reinforce the importance of being prepared for the lecture, a new activity was introduced. Students were expected to do a reading quiz on the WebCT at the beginning of every week. The multiple-choice questions in the reading quiz consisted of basic and simple ideas on the week's topics. The grade of the quiz combined with the tutorial and homework contributed to 10% of the total mark for the course.

The computer/WebCT/Internet resources were rated only 2.7 to adequately support student learning. There were six comments expressing the benefit of the reading quizzes on the WebCT. Students writing these mentioned that the reading quizzes "get you to have a good look thru (sic) the textbook", "provided an incentive to read the book" and "allowed me to have a better understanding". Only a few students seemed to recognize the purpose of this activity because the averse comments outnumbered the positive comments. There were 20 students putting forward their complaints. Four comments represented each of the following: "no WebCT", "it's useless and not helpful", "it's a waste of time". Two students expressed their frustration on the amount of the reading and two others were concerned about the access to the computer. There were five comments addressing the questions, which were viewed to be hard, abstract, unclear, or even “too few to gain a high grasp of the topic”. These comments may reflect the rather unfavorable student rating mentioned above.

Reading before the class was not formally encouraged in the previous physics course. The on-line quizzes, being new to probably most students, may have caused some anxiety. The students at this stage may not be aware that preparing for a lecture and familiarity with computers are essential in their study. This should be reinforced as early as possible. Being a good student requires self-discipline in time management. A few comments that the WebCT reading quizzes was a waste of time and easy to forget to do possibly indicated a lack of motivation to spend more study time outside the class for some students. The reading quizzes were made available only for a certain period of time at the beginning of the week. Students would miss the quiz if they did not pay attention to the timetable. Assigning a variety of purposeful tasks with different due dates for completion may serve as an exercise for students to adhere to good time management. This, also, should be encouraged from the beginning.

Peer discussion during in-class demonstration

In order to engage the students more actively, a Peer Instruction (Mazur, 1997) style of approach was adopted. From time to time, the lecturer posed multiple-choice qualitative questions on the overhead projector (OHP). Students were given time to discuss with their neighbours and asked to show the answer by putting up a 10×10 cm card. Every student was provided with a set of six cards, each of which contained an over-sized letter (A, B, C, D, E or F) indicating an answer choice. This activity was intended to break the monotony of passive listening, to force the students to think about a concept and to explain it in their own words to their peers. Most in-class demonstrations were accompanied by this activity. In such case, the lecturer stopped the demonstration at some point and then asked the students to predict the outcome (Sokoloff & Thornton, 1997). After the students put up the card indicating their chosen letter that represents the answer, the lecturer proceeded with the demonstration followed by some explanations. Any discrepancy between the prediction and the observation was expected to induce cognitive conflict that may lead to a better understanding (Posner, Strike, Hewson, & Gertzog, 1982).

Eight students found this activity to be good or helpful while four considered it to be a waste of time. One of the unfavorable comments even suggested spending the time to “increase understanding of the material … and to gain more in-depth understanding from a book” instead of wasting time “on question cards”. The perception of this student was the opposite of the intended purpose of having qualitative problems discussed with the peers. As to the demonstration, there were nine appreciative comments, including one, which asked for notes accompanying the demonstrations. This student might be impressed with the questions asked to predict the outcome and the explanation followed. Students rated 3.6 for the statement that “the lecturer made good use of examples and illustrations to explain difficult concepts”. There was only one comment suggesting otherwise: “it was not necessary to follow them with many questions which consume valuable time”.

Students were apparently more inclined to put forward their concerns about certain activities if they were assessed. There were more expressions of complaint about the tutorials and reading quizzes than the comments appreciating those activities. On the other hand, the number of students mentioning that peer discussion and in-class demonstration were useless was very small as compared to that realizing their benefit, at least as shown by the remarks written in the survey. This indicates that students will pay more attention and feel more involved if their work is recognized in some way or the other. It sounds trivial, but it suggests that appropriate and well-designed tasks are essential to enhance the student learning experience.

Pre-lecture downloaded hand-out

As a consequence of the modification, there was a change in the presentation of the material. In the PHYS111 course of the previous semester, the students copied the material written by the lecturer on the OHP slide during the lecture. In the first half semester of PHYS112, the topics were outlined on the prepared OHP slides, the copies of which could be obtained *after* the lecture. Despite the expectation to read the textbook before the class, some students seemed to experience difficulty with this kind of presentation. To accommodate this concern, the presentation was changed again in the following half semester. Students could view on the WebCT and print out *before* the lecture the information containing important items of the material taken directly from the textbook. The purposes were to give the students a good overview of the day's material, to free them from writing too much thus enabling them to engage in more constructive activities such as thinking over the questions and having discussion with their peers, and to provide more time for the lecturer to do other activities.

The rating for the following statement: "As aids to learning, the lecturer's hand-outs have been valuable" was 3.9. Twenty-two comments indicated that the hand-out printed out from the WebCT was helpful. Some students apparently realized the intention of the lecturer in making the hand-out available before the lecture. They mentioned, for instance, "… made listening and learning a lot easier rather than spending the whole lecture trying to write notes" and "… gave something to refer to if I got stuck". There were, however, 12 other comments, which expressed a negative feeling towards the hand-out. Three simply mentioned their dislike for such a practice. Three others preferred to write all the material out during the lecture because "it is very expensive to print that many notes out" or "WebCT is a pain and not very reliable". There were two students who felt that having the material beforehand made the lecture useless. As to the content of the hand-out, three comments suggested that it should contain more, such as "more writing … (more interactive)", "approach … from a different angle than the textbook" and "in depth explanation".

Although a few students expressed their desire to have the material presented in the old way, the majority seemed to be comfortable with the new system. The student rating on the survey indicated that the hand-outs which could be printed out from the WebCT before each lecture were perceived to be helpful. It is true that the explanation of the material in the hand-out still took a considerable amount of time, i.e. about 75% of the 50 minutes in each lecture. When they were asked to have discussion with their peers, the students were quite willing to do so, although their enthusiasm seemed to fade towards the end of the semester. This fading enthusiasm could be attributed to the fading interest in a novel activity, the increasing level of difficulty of the material or the accumulated amount of work from other courses.

Conclusion

This study reported the students' reactions to some elements of a modification in an introductory physics course. The purposes of the modification were to get the students well prepared for the course, to engage them more actively during the lecture and to provide them with more qualitative problems. Many previous reports noted that students could be resistant to any reform in the teaching approach because they have been comfortable with the existing method. Based on a course survey administered at the end of the semester, the computer-related task was perceived to be not very helpful while the hand-out was voted to be helpful by the majority of the students. They showed more concern with tasks, which were both new and assessed. A few student comments regarding the activities perceived to be not helpful indicated a problem of time management outside the class. The modification apparently had an impact on the students' involvement inside as well as outside the class. In general, the students were quite adaptive to the change in teaching approach. This can be considered as a promising initial step in helping the students to learn better.

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