The investigation of the compatibility of students' learning preferences with a pilot peer learning program in an undergraduate Physics course.

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Abstract

There have been major changes in the modes of communication over the past decade, aided by enormous improvements in technology and access to information. Students now, more than ever need to be able to adapt readily to this changing environment. In order to prepare students to cope with these new situations educators must also make changes in the way they teach. Consequently, this research study examines the relationship between learning preferences of first year undergraduate physics students and the implementation of a peer learning program.

A new teaching system was designed and initiated where students experienced two different teaching styles in their Introductory Physics tutorials. In the first style, peer learning was implemented, where the students worked in cooperative groups with the teacher as a facilitator of learning. In the second, students experienced traditional teaching without peer learning. This paper aims to investigate the compatibility of students' learning preferences with the pilot peer learning program in Introductory Physics modules using mixed methods. Both quantitative and qualitative data on student performance and attitudes was collected. Students learning preferences were measured using a modified version of the attitudinal survey by Lewis and Seymour (1997) and utilized to evaluate their learning styles compatibility with the peer learning program. It is intended that the results of this project will provide valuable guidelines for the implementation of peer learning in Physics at the Science Learning Centre in the University of Limerick and within other academic institutions.

Introduction

Peer learning is where the students work in cooperative groups and the teacher operates as a facilitator of learning. Peer learning has been popular in teaching and learning for many years. As both a pedagogy and learning strategy, it had been frequently adopted, adapted and implemented in a wide range of academic courses particularly in the sciences [1]. Peer learning promotes critical thinking through discussion, clarification of ideas and evaluation of others' ideas, with the teacher as a facilitator of learning. Peer learning groups are structured and managed to maximise the active and appropriate participation of all students in the group [2]. Peer learning can be easily incorporated into the present structure of teaching physics.

Many factors impact on how well people can learn. Gardner's [3] theory of multiple intelligences has led to a broader understanding of how people learn.

[1] Arendale, D., 2004. Postsecondary Peer Cooperative Learning Program Annotated Bibliography. *Annotated Bibliography of Peer CooperativeLlearning Programs*

[2] Johnson D. W., Johnson R.T., and E. J. Holubec, 1986. *Circles of Learning: Cooperation in the Classroom*, interaction, Edina, pp 6-10.

[3] Gardner, H., 1993. *Frames of Mind*, Fontana press, London

Academic work has traditionally focused on the first two intelligences – linguistic and logical/mathematical and neglected the others [3]. Kolb (1984) argued that learners learn best when they are active, take responsibility for their own learning, and can relate and apply it to their own context. He also argues that it is also necessary to reflect on the experience, through discussing it with others to increase the learning potential [4]. Understanding ones preferential learning style is useful for facilitating an individual's optimum learning environment. However, other factors also contribute to the learning outcomes such as interest and motivation.

Background

In light of current interest in peer learning, a pilot study was undertaken to discover the effectiveness of peer learning in Introductory Physics modules using quantitative and qualitative data on student performance and attitudes. The study is based on Introductory Physics PH4022, where basic mechanics, heat, properties of fluids, and waves are studied in a 15-week semester. Peer learning is compared with students experiencing a traditional teaching style in their tutorials. The previous year's class of Introductory Physics PH4022 (2004) was used as the control group since they experienced traditional methods only. The final examination result's was the data utilised from the 2004 group. Worksheets were devised using concept questions. Concept questions are designed to expose common difficulties in understanding the material. Students would not simply answer the question by deciding on what formula to use, rather, what physics concepts and principles should be applied to the problem. Concept questions are often seen as difficult for even the best students as they involve applying physics concepts and making decisions. However, they make ideal peer learning questions since a group can work together, pool ideas and share the problem.

Sample

The sample under investigation is first year Environmental Science students (N=22) majoring in Chemistry. Attendance at the tutorials was good (68%, N = 22). The author selected the groups on recommendations made by the FLAG initiative [5]. The author formed heterogeneous groups based on students' previous experience with physics. Five students had previously studied physics the remainder (N=17) of the group had not.

Instrument for data collection

The effectiveness of the peer learning method employed was monitored through a number of means: pre/post questionnaire, Force Concept Inventory (FCI) pretest/post-test and final examination.

Questionnaires and Force Concept Inventory (FCI) test were administered to the group during the tutorials. The questionnaire used in the pilot study was a modified version of the attitudinal survey developed by Lewis and Seymour [5]. The questionnaire contained Likert-scales, on a scale ranging from 'strongly disagree' to 'strongly agree' and questions on; learning preferences, the students' perception on the nature of knowledge, their own role in learning, improvements to be made to the tutorial.

[4] Jaques, D., 2000. *Learning in groups: a handbook for improving group work*, 3rd ed, Kogan Page, London.

[5] NISE (National Institute for Science Education) – College Level One. 1997. *Collaborative Learning*: *Small Group learning Page* [online]. Field-test Learning Assessment Guide (FLAG), University of Wisconsin-Madison. Available from: http://www.flaguide.org/intro/intro.php

Halloun and Hestenes designed a multiple choice mechanics diagnostic test called the Force Concept Inventory (FCI). The diagnostic test is widely used to gauge the initial knowledge state of undergraduate students, as well as to quantify the effect of instruction on the knowledge state of the students [6]. A modified version of the FCI was used in the pilot study. Due to time constraints ten concept questions selected from 30 questions were used. On designing the diagnostic test, Halloun and Hestenes planned the questions on the basis of students' common misunderstandings. The alternatives in the answers were selected from a pool of students' incorrect answers and reflect the most common misconceptions encountered. The questions cover a variety of basic concepts on the conceptualisation of motion.

Results

Table 1 shows the results from the FCI (Force Concept Inventory). There was no significant increase (t = 4.749, df = 20 *p* =0.277) in the FCI scores (3% gain) from the pre and post-tests.

Table 1. *Force Concept Inventory PH4022 (2005) results.* [1]

	N	Mean %	% Gain (post-pre)	g%	Max %	Min %
FCI pre	18	26			60	10
FCI post	11	29			60	10
			3	2		

The initial state of the mechanics knowledge of the students in the group are reflected in their pretest scores, which were 26%±12.06 (mean±standard deviation). The post-test scores 29%±13.75 (mean±standard deviation). There was a significant difference (t = 4.749, df = 20 *p* = 0.000) between the exam results of the two groups 2004 class; 65.86±16.91 (mean±standard deviation) and 2005 class; 61.29±17.45 (mean±standard deviation), see table 2.

Table 2. *Statistical data from the exam results.*

Group	No. of students	Exam mean (s.d.)	Midterm mean (s.d.)
Control 2004	21	65.86	not available
		s.d. (16.91)	not available
Peer learning	21	61.29	60
		s.d. (17.45)	
Statistics			
t		4.79 (p = 0.000)	
df		20	

The scores from the pre and post questionnaires were compared by examining the difference in the mean scores relative to the spread or variability of the scores (Appendix A). Independent *t*-tests were used as the samples were unmatched and unrelated. There was a significant difference (t = -2.115, df = 26, p= 0.044) in the responses from the pre to post questionnaire on the question of ' doing hands-on activity'. There was also a significant difference in the response to the 'applying ideas to new situations' (t =-1.632, df = 26, p= 0.006) and 'can see how concepts relate to one another (t =-3.128, df = 26, p= 0.004).

[1] Notes: N = pupils numbers, FCI = Force Concept Inventory test, score out of 10, pre = test given on first tutorial, post = test given on last tutorial, % Gain = difference in % score for pre and post FCI test, g = fraction maximum possible gain achieved [g = (post - pre)/ 100 - pre)

The effect of the peer learning method is represented in the questionnaire responses in table 3. 20% of respondents disagreed with 'I learn well by working on my own'. 10% of respondents disagreed with the statement 'working with others increased my interest in physics.

Table 3. *Frequency response of effects of the peer learning tutorials*

	Working on own	Working in a group	Enjoyed this course	Working with others increased interest in physics	Interest in physics increased	Peer learning made physics easier to learn
disagree	20.0%			10.0%		
neutral	30.0%	10.0%	20.0%	10.0%	30.0%	20.0%
agree	20.0%	50.0%	60.0%	60.0%	30.0%	40.0%
strongly agree	30.0%	40.0%	10.0%	20.0%	40.0%	30.0%
not applicable			10.0%			10.0%

Conclusion

The main finding of the pilot study is that no significant increase in the students' FCI scores resulting from the implementation of peer learning. There was a significant difference ($p = 0.000$) in the exam results, 2005 group did not perform as well. However, the students' attitude to peer learning was positive and their perception of Physics in general improved. The results are consistent with Samiullah's [7] findings of the relationship between improvement in grades and implementing a similar peer learning program. This is an unexpected observation and does not agree with Mazur, Halloun and Hestenes. Their study shows 'dramatic improvement in student performance' [8]. There are several possible reasons for the conflict in findings these include sample size and time constraints.

There was a noticeable improvement in the students' attitude to Physics and to peer learning as the semester progressed. Although the positive attitude of the class did not have any noticeable effect on the test scores it did however, improve the atmosphere in the classroom. Increased interaction among the students made them more comfortable in class and resulted in greater participation. Peer learning creates an environment "*that involves students in doing things and thinking about the things they are doing*", [9] and reaches students who otherwise might not be engaged. Peer learning is one teaching strategy among many that makes learning an active and effective process. This paper's findings suggest that the peer learning method employed is equally effective in providing students with the content of the course as the traditional teaching method.

[6] Heller, P., and Hollabaugh, M., 1991. Teaching problem solving through cooperative grouping. Part 2: Designing problems and structuring groups. *Am. J Phys.* 60 (7), 637 – 644

[7] Samiullah, M., 1994. Effect of in-class student-student interaction on the learning of physics in a college physics course. *Am. J Phys.* 63 (10), 944 – 950.

[8] Mazur, E.,1997. *Understanding or memorization: Are we teaching the right thing* in *Conference on the Introductory Physics Course on the occasion of the retirement of Robert Resnick*, Ed. Jack Wilson [online]. pp. 113-124 Wiley, New York

[9] Bonwell, C., & Eison, J. (1991). *Active learning: Creating excitement in the classroom* (ASHE-ERIC Higher Education Report No. 1). Washington, DC: George Washington University, p. 2

APPENDIX A

Table 5. *Statistical analysis of pre and post questionnaires*

	Group	N	Mean	Std. Deviation	Std. Error Mean
Homework assignments	Pre test	18	3.2222	.73208	.17255
	Post test	10	3.6000	1.07497	.33993
Diagrams and other visual media	Pre test	18	3.7222	.75190	.17723
	Post test	10	4.6000	.96609	.30551
Computer based materials	Pre test	18	2.9444	1.10997	.26162
	Post test	10	3.5000	1.35401	.42817
Reading a good textbook	Pre test	18	3.2222	.87820	.20699
	Post test	10	3.6000	1.17379	.37118
Working with lab partner	Pre test	18	3.5556	.98352	.23182
	Post test	10	4.1000	.56765	.17951
Tutorial aid	Pre test	18	4.1667	.61835	.14575
	Post test	10	4.5000	.70711	.22361
Doing hands-on activities	Pre test	18	3.7222	1.17851	.27778
	Post test	10	4.7000	1.15950	.36667
Listening to lecture	Pre test	18	3.3333	.90749	.21390
	Post test	10	3.8000	.91894	.29059
Completing lab notebooks or lab reports	Pre test	18	3.3889	.84984	.20031
	Post test	10	4.1000	1.66333	.52599
Reading and re-reading material	Pre test	18	3.7778	1.00326	.23647
	Post test	10	3.9000	.99443	.31447
Work problems in the book	Pre test	18	3.8889	.83235	.19619
	Post test	10	4.2000	1.31656	.41633
Apply ideas to new situation	Pre test	18	3.8333	.98518	.23221
	Post test	10	5.2000	1.39841	.44222
Good grade on exam	Pre test	18	4.3333	1.08465	.25565
	Post test	10	5.1000	1.37032	.43333
Explain the ideas to someone else	Pre test	18	4.1667	.61835	.14575
	Post test	10	4.8000	1.31656	.41633
Can see how concepts relate to one another	Pre test	18	3.8333	.92355	.21768
	Post test	10	5.1000	1.19722	.37859