Web Page to Improve Feedback in the Teaching of Physics in Baccalaureate: Partial Results of a Research Seed Project

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Abstract*– The purpose of this study was to apply a feedback based on the peer instruction through the use of a web page developed by students of the Bachelor's Degree in Education Sciences with a major in Physics and Mathematics of the University of Guayaquil in the teaching of the concepts of Work and Energy to improve students' performance. This web page emerges as a result of a research seed project and it aims to provide a resource for the teacher through which effective feedback can be made to students during the teaching-learning process. The subjects of study were 120 students enrolled in the First Year of Unified General Baccalaureate of Ecuador who are studying the subject of Physics. Their ages are between 14 and 16 years, including 57 men and 63 women. The procedure followed during the procedure was as follows: (1) to present the intervention to the experimental group and the control group to the traditional model (2) apply the performance test. The Welch's t-test gave the result of $p < 0.0001$. Therefore, the null hypothesis is rejected and the research hypothesis is accepted. In addition, it can be inferred that the results obtained are due to the feedback made by the teacher through the use of the web page developed in the present research seed project.

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I. Introduction

Having to teach in large classes has given way to numerous researches in the teaching of physics in recent years. Several studies have shown that the number of students in a Physics class has an impact on the teaching and learning process. One of the main factors affecting the teaching and learning of physics in the classroom is the large number of students [1]. Large classes make it difficult for the teacher to provide immediate and quality feedback to students as it is complicated to provide individual attention to students who need it [2]. It is important for students to know how well they are doing as they learn. This is because knowing that they are doing well generates in students a sense of accomplishment that motivates them to learn more. Likewise, it is also important for students to know when they have made a mistake so that they can learn from it and take corrective action. Therefore, it is absolutely essential for teachers to monitor student learning and provide immediate and effective feedback.

Failure to provide good feedback often leads to failure to address alternative conceptions of students [3]. However, the great challenge is that teachers can provide effective feedback to students without having the burden of spending long hours reviewing individual student work. For this reason, rapid feedback methods have been developed so that it is possible to diagnose students' conceptual development and to respond to common problems without having to spend long hours checking individual students' work.

One of these methods is Peer Instruction (PI), which has a student-centered approach. The PI modifies the lecture format and includes questions designed to involve students and discover the difficulties they have with the study material presented [4]. In addition, PI provides a structured environment for students to express their ideas and clarify their ideas by talking to peers. By working together to learn new concepts and skills in a subject, students create a more cooperative learning environment which favors the learning focus in a classroom community environment [5]. Some research studies suggest that this type of collaborative learning environment could help promote deeper learning as well as greater interest and motivation [6].

On the other hand, PI could also help students develop better metacognitive skills as they could check their own understanding of pre-class reading in addition to classroom questions. The methodology helps students when they are not clear about the concept, when they are unable to answer a question about reading, or when they can't give full explanations to their classmates during the class discussion [7]. With this type of internal formative feedback, students could learn to better evaluate their own understanding during the learning process. PI encourages students to take responsibility for their own learning. In an investigation of students' attitudes in the classroom when using PI, a significant change in class attitudes was found. Discussions to "convince their neighbor" systematically increased both the percentage of correct answers and the confidence of students [8]. Additionally, research showed that student satisfaction also increases.

The PI procedure during the class is framed around short multiple-choice conceptual questions, known in English as ConcepTest type questions. Questions should be designed to take advantage of the experiences and thinking that the students bring to the class about the material so that they themselves can recognize their ideas and build upon them.

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These questions are aimed at solving students' difficulties and promoting students' thinking about challenging concepts [4].

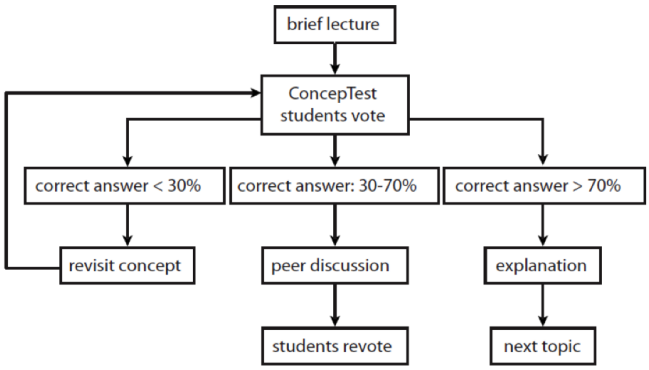

Fig. 1 PI implementation procedure [9]

After a brief presentation by the instructor, the focus shifts from the instructor to the students, the instructor encourages students to think about the material they present through a ConcepTest. After 1 to 2 minutes of thought, students will choose an individual answer. If very few students respond with the correct answer, the instructor can review the concept using lecture or try a different ConcepTest type question. If the vast majority of students respond correctly, the instructor usually gives a brief explanation and moves on to the next topic or ConcepTest. If a moderate percentage of students respond correctly to ConcepTest, the instructor asks students to interact with their neighbors and discuss their answers to re-vote for the same question.

With constant feedback about the lesson, the instructor can monitor student progress and help guide students to use their ideas earlier to understand new concepts and theories. In addition, PI flexibility makes it easier for instructors to spend more time on concepts that are difficult for students, giving more concrete presentations.

In order to be able to develop the IP in the present work, a web page was designed by students of the third semester of the Bachelor's Degree in Education Sciences with a major in Physics and Mathematics of the University of Guayaquil, which showed ConcepTest questions about the topic of Work and Energy for First Year Students of Unified General Baccalaureate in Ecuador. The students responded by means of bookmarks marked with the four options: A, B, C, and D. After the first response, it was evaluated if an explanation was needed and to go on to the next topic, to work in pairs or to review the concept, according to the scheme shown above in Fig. 1.

This web page is the end result of a Research Seed Project. These types of projects are born in the classroom and then presented in an internal call from the University of Guayaquil. It is then evaluated by a scientific committee, both in the investigative part and in the budget until it reaches the approval and development phase of the same. Among the direct beneficiaries of the project are physics students who are attending the Unified General Baccalaureate program in Ecuador. According to data from the Ministry of Education of Ecuador, in 2012 there were about 500,000 students enrolled in Unified General Baccalaureate in all of Ecuador, of which 60% have access to the internet in their educational institutions [10]. That is, it will be about 300,000 students between 15 and 17 years. It will also benefit parents, physics teachers and even universities that deliver careers related to Physics. Finally, taking into account that the web page is virtual, it can be used both locally and internationally.

A. Purpose and hypothesis

The purpose of this study was to apply a feedback based on the peer instruction, IP, through the use of a web page developed by students of the Bachelor's Degree in Education Sciences with a major in Physics and Mathematics of the University of Guayaquil in the teaching of the concepts of Work and Energy to improve students' performance. The hypotheses were as follows:

The research hypothesis is: Those students to whom the intervention is applied perform better than those students to whom the intervention is not applied.

The null hypothesis is: Those students to whom the intervention is applied have the same performance of those students to whom the intervention is not applied.

II. Methodology

A. Subjects

The subjects were 120 students, including 57 men and 63 women. All were taking the First Year of Unified General Baccalaureate of Ecuador in an educational institution of the city of Guayaquil. Their age is between 14 and 16 years.

B. Instruments

A Web page containing multiple-choice questions was used to apply PI-based feedback to the experimental group.

The instrument to measure student performance was a multiple choice test consisting of 40 items about the Work and Energy unit.

C. Procedure

To facilitate feedback based on the PI model, the class of the experimental group was made in the computer lab of the educational institution and sat in pairs to the students. The control group class was performed in the usual classroom.

The procedure followed during the intervention was as follows: (1) Present the intervention group and the control group to give the class according to the traditional model. The content and problems proposed were the same for both groups, the only thing that varied was how to present them. This was done on the first day, with a duration of two hours of class of 45 minutes each. (2) Apply knowledge test to both

experimental and control groups. The knowledge test was the same for both groups. This was done the day after the intervention, in an hour of class of 45 minutes.

III. Results of the Statistical Analysis

The statistical analysis applied in this investigation was the Welch's t-test with a significance level $p < 0.05$.

Fig. 2 shows some results of the performance test administered to the experimental and control group.

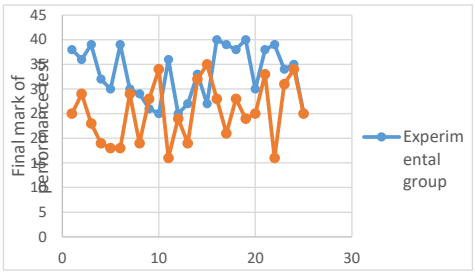

Fig. 2 Comparison of the results of 25 individual performance tests.

The Welch's t-test gave a value of $p < 0.0001$ therefore the null hypothesis is rejected and the research hypothesis is accepted. Table 1 below shows a summary of the results of the t test for the 120 students, 60 of the experimental group and 60 of the control group.

TABLE I
STATISTICAL DATA OF THE PERFORMANCE TEST

Group	Mean	Standard deviation	t	df	P < 0.0001
Experimental	33.20	5.39	4.89	47	
Control	25.32	5.98			

The calculated t-value was 4.89 with 47 degrees of freedom. This value is higher compared to $t_{critical} = 2.0118$ which corresponds to a probability of 0.05. In this way, the null hypothesis is rejected and the research hypothesis is accepted.

IV. Discussion y Conclusion

Evaluating the results obtained after intervention in the students in terms of conceptual learning, it was found that classroom peer instruction is more effective in the development of students' conceptual understanding than the traditional master lecture method. The results of the study imply that the use of rapid feedback methods such as PI have a positive effect on the mastery of student content.

One of the limitations of the study is that the motivation or interest of students in the subject of Physics, which is taught in the first year of baccalaureate, was not measured. Interest, significance and relevance are measures of intrinsic motivation [11], and not only depends on the academic success in the subject. It is likely that the PI did not affect the interest and the value of the necessary perception required to promote change motivation.

Other limitations of the study are that it did not take into account variables such as student behavior, previous knowledge, quality of the educational center in which the test is carried out and validation of the questionnaires; so the results should be checked in subsequent studies or validations.

On the other hand, we can also note that the discussion generated by the PI is more effective than the discussion at the class level, since in the latter the students are not given the opportunity to generate their own conceptualization or mental model, in relation with ConcepTest questions. Therefore, there is less conceptual conflict when the peer discussion begins. This is because students are more likely to accept the dominant interpretation [12]. However, more research is needed to confirm this hypothesis.

In addition, it is important to note that this intervention was carried out thanks to a Web Page that was developed as a result of a Research Seed Project raised by students of the third semester of the Bachelor's Degree in Education Sciences with a major in Physics and Mathematics of the University of Guayaquil. Thus, the emphasis is on the use of projects as a central, non-peripheral issue in the curriculum or the planning of studies of the subjects taught in the classroom. This instructional strategy focuses on issues or problems in which students meet and discuss the core concepts and principles of the career they study [13]. These projects have the capacity to involve students in constructive research as long as real, unschooled problems are used [14]. This will result in students experiencing the learning of an integrated whole, rather than a series of separate blocks across the hours of the day. However, it is necessary to mention that it is not a job that is limited to teaching, but can also lead to a commitment of the university to local communities, families and businesses.

It should be emphasized that the present paper does not describe the process of elaboration in the classroom of the project in question. Such information can be found in [15].

Finally, we hope this work inspire more teachers to bring project-based learning to their class, and that it has provided ideas, tips and tools to engage and challenge their students.

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