Supporting students' learning with the use of pencasts in teaching optics

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Supporting students' learning with the use of pencasts in teaching Optics

S.M. Gomez Puente[a1], J.T. Kohlhepp[b]

a - b Eindhoven University of Technology, Den Dolech 2, 5600 MB, Eindhoven, the Netherlands

Abstract

Computer-based education has been integrated recently in the second year bachelor course, *Optics*, in order to facilitate learning physics concepts. The motivation behind was to provide students with online support for better understanding of theory and concepts for the preparation of the final exam. A second rationale was to increase the pass rate by meeting individual learning needs. The educational approach is based on introducing blended-learning tools that allow the teacher to zoom in difficult parts of the topic and provide explanations while addressing lacunas in prior knowledge. The blended-learning approach consisted of online quizzes, formative feedback and assessment. In addition, we incorporated pencasts, i.e. short recordings on specific topics. The purpose was to enhance the self-study time and help students during the preparation of exams. In this paper, we present the experience of the physics course *Optics* in which students' gains in some exam questions is higher than in previous years.

Keywords: Blended-learning; formative feedback and assessment, physics conceptual understanding; technology-based education

1. Introduction

The initiative to integrate computer-based education in the sophomore course, *Optics*, was motivated by the increased number of students and the need to respond to individual learning problems. The teaching staff incorporated online quizzes in a moodle platform as a form of formative feedback and assessment. The advantages of the weekly short quizzes is that students get access to practice tests on concepts and theory given during the lectures. Furthermore, students apply the knowledge gained in the lectures in solving problems during the instructions. The additional relevance of this computer-method is that students practice with questions that represent problems at the level of the final exam, on the one hand. On the other hand, students get immediate feedback on development that helps to monitor study progress. In addition, students invest in quality of study time. However, despite the integration of blended-learning methods, the pass rate of the *Optics* course was consistently low. This asked for a different approach to keep supporting students during the self-study time, and specially, to support students for the preparation of exams.

[1] Corresponding author's address: Eindhoven University of Technology (TU/e), Den Dolech 2, 5600MB, Eindhoven, the Netherlands
e-mail: s.m.gomez.puente@tue.nl

We conducted an experiment to enhance students during the preparation of final exams. This experiment consisted of recording pencasts (short videos on specific parts of theory) so that students can use these resources as study material for the study time. Regarding the students' score in questions on electromagnetics waves and geometric optics, we observe a positive change regarding the concept on geometric optics where students score higher this year than last year.

We present in the coming sections how this experiment has taken place. Moreover, we also reflect on students' gains regarding some exam questions and we compare this with previous years. Finally, we present some conclusions that can open up new venues for further research.

1.1. Theoretical considerations

The use of computer-based education in teaching physics at the Eindhoven University of Technology (TU/e), the Netherlands, is not new. Since 1996 the integration of technology in education to support students' conceptual understanding has been extensively applied in physics courses (Poulis & Massen, 1998). The added value of applying methods in higher education such as the audience response systems, the so-called clickers, has resulted in better understanding of concepts (Gomez Puente & Swagten, 2012). Likewise, it influences the quality of self-study time and the interaction in classroom settings. These interesting outcomes are supported as well by research on computer-based learning (Lewin, 2011) that shows students' gains in problem solving and in learning concepts (Crouch & Mazur, 2001).

Moreover, there are numerous research studies highlighting how students learn when they are engaged in active learning (Bransford, Brown & Cocking, 2000). Computer-based education and simulations have been widely used to learn students physics and more importantly to clarify misconceptions (Paul, Podolefsky & Perkins, 2013). Literature on teaching physics in an interactive classroom emphasis that students conducting experiments with a visual display facilitates the process of visualizing the physics with graphic animations that resemble science and how science works (Paul, Podolefsky & Perkins, 2013). Furthermore, results from empirical research show how blended-learning in combination with educational approaches such as flip-the-classroom can enhance learning (Baepler, Walker & Driessen, 2014).

2. Method

We conducted a pilot experiment in the academic year 2016/2017 consisting of using six pencasts, i.e. short recordings, on specific explanation of difficult concepts on electromagnetics waves and geometric optics. The purpose of this experiment was to provide students with online material that supports their understanding during the self-study time to prepare the final exams (See Figure 1).

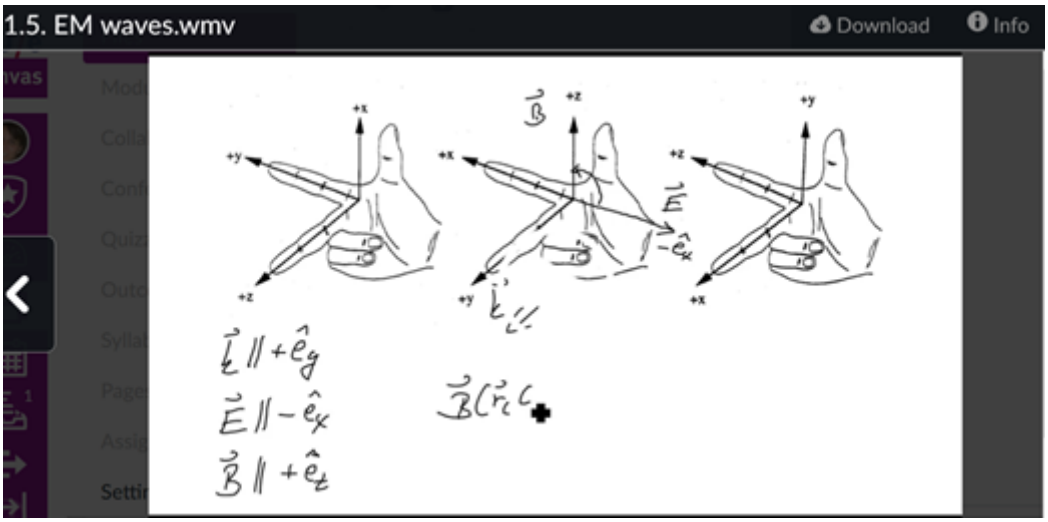


Figure 1. Image of a pencast on the topic Waves.

2.1. Procedure

To assess whether this blended-learning method may have influenced students' study performance, we conducted a test analysis and compared exam questions about which some pencasts were recorded. In addition, we compare the pass rates of different cohort of students in different academic years. Finally, we assessed students' satisfaction by collecting perceptions on pencasts and whether this method was useful to prepare exams. In the next section, we provide an overview of results.

3. Results

To find out whether the use of pencast as a new method supported students' learning has had influence on students' test performance, we compared the pass rate of this academic year with the results of previous years. As shown in Table 1. pass rates of final test (first try) in academic year 2016/2017 are considerably higher than in previous years. Zooming in the results we observed that the pass rate of the Optics course in 2016/2017 is 62% while in 2015/2016 was 40%, in 2014/2015 was 46%, and in 2013/2015 was 47%. Results this year indicate an increase up to 62% which is a significant positive outcome.

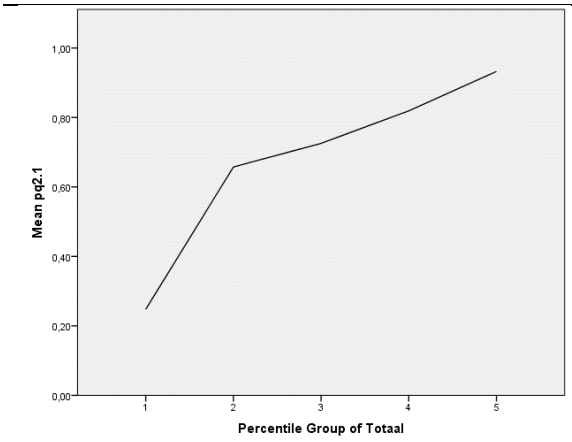
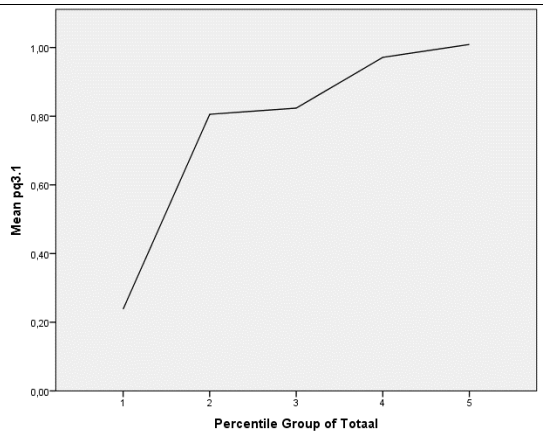
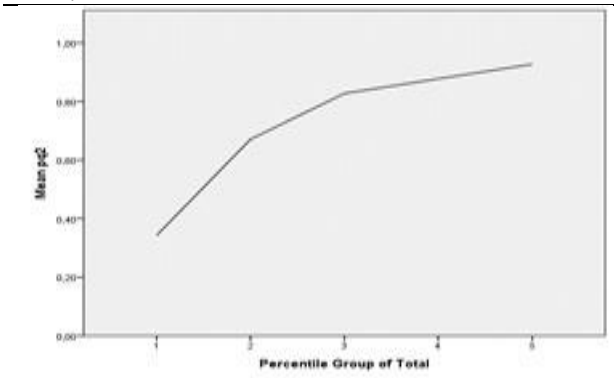
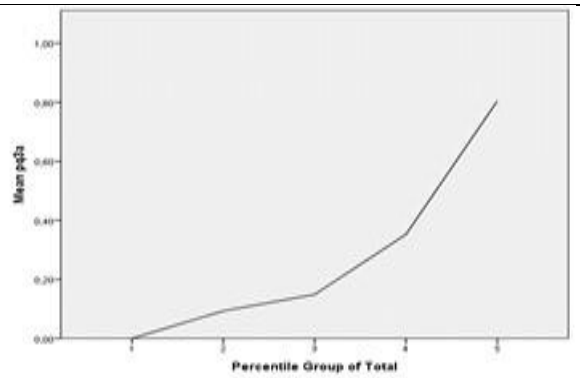
Table 1 Overview pass rates in different academic years

Course	Date final exam	Total number students	Average grade	Pass rate	Total course performance
Optics	31-Jan.-2014	66	5.29	47%	
	10-Apr-2014	39	5.33	54%	76%
	29-Jan-2015	115	5.22	46%	
	9-Apr-2015	69	3.80	36%	64%
	28-Jan-2016	176	5.19	40%	
	7-Apr-2016	100	4.78	40%	61%
	2-Feb-2017	169	5.86	62%	
	11-Apr-2017	52	5.32	46%	

Moreover, we conducted test analysis with the Statistical Program for Social Sciences (SPPS) of the final test and compared results of the test analysis in 2015/2016 and 2016/2017. The interest was to see whether there are differences in students' performance in the same type of test questions in the final exam for which specific pencasts have been recorded this year for the first time.

In the graphs below we observe that regarding the students' score in questions on electromagnetics waves and geometric optics, there is an improvement on the concept on geometric optics. In this questions students score higher this year than last year (question 3.1. of the final exam on the right column). However, we perceive little change in question 2 of the final exam (left column) when comparing the last year of students' test performance on this course. The horizontal axe represents the groups of students who have participated in the exam. We divided the group in 5 sub-groups which correspond to the distribution of grades in the final exam. In other words, students in group 5 are those who got a 9 or higher in the final exam, while group 1 represent students who got a grade lower than 3. The vertical axe represents the percentage of students of a specific group scoring on a specific exam question. This method allows us to perceive a clear difference among students.

Table 2 Overview of final exam questions which have been supported with pencasts in 2016/2017 compared to questions which were not supported with similar blended-learning methods

2016/2017	
	
2015/2016	
	

Finally, we evaluated the course with a Likert-scale questionnaire to perceive students' satisfaction on pencasts. Furthermore, students' satisfaction on the e-method pencasts is positive as students perceive the method as useful for the preparation of the exam and to clarify theory and concepts (3.5 and 3.5 on a of 1-5 Likert scale according to students' questionnaires). See Figure 2.

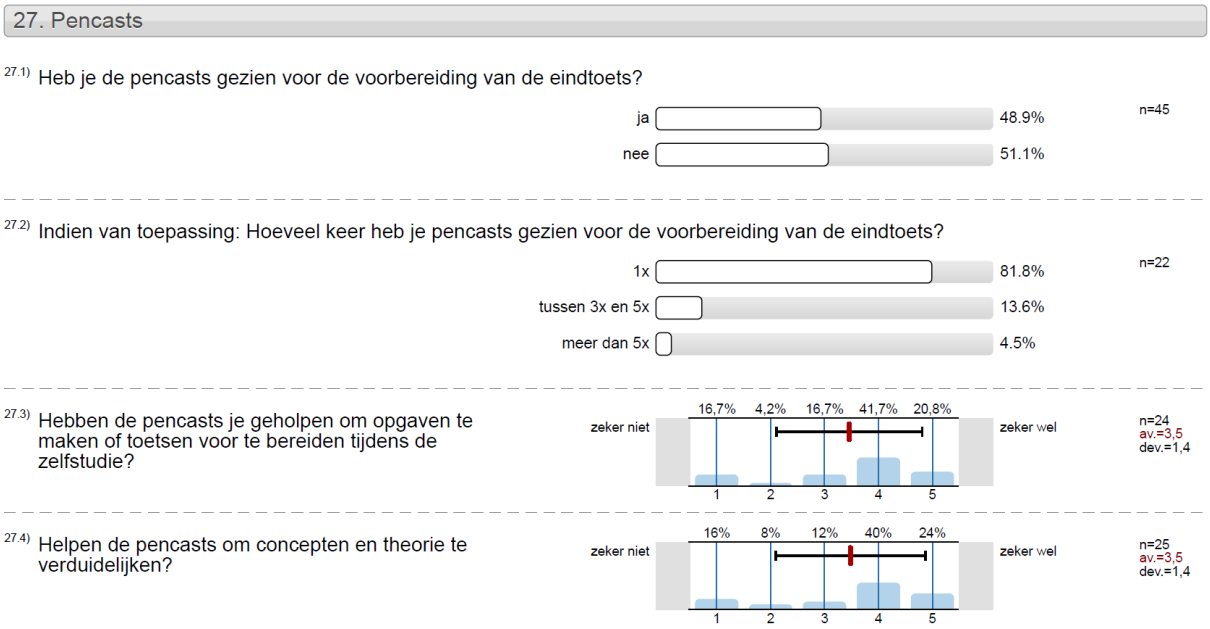


Figure 2. Students' response in course questionnaire regarding satisfaction Pencasts (translation of questions see foot note[2]).

4. Conclusions

The significance of this study is twofold. First of all, pencasts are suitable methods that support students' learning in the self-study time to prepare for exams. Secondly, this method may be regarded as appropriate to tackle students' individual problems in learning the physics content of this course. We conclude therefore that blended-learning tools may have a positive influence on students' understanding. Besides this, it may be added that in order to have a successful experience the instructional design of the course is of paramount importance. Despite the positive results, we are cautious to make strong conclusions about the influence of the pencast in this course, as there were other educational elements that were introduced in this academic year such as a new book and some additional lab assignments that may have also influenced positively students' yields.

[2] Translation students' questionnaire: Q 27.1) Have you watched pencasts to prepare he final test? Q 27.2) If applicable, how many times have you watched the pencast to prepare the final exam? Q27.3) Have the pencasts helped you to prepare the exam and solve problems during the self-study time? Q27.4) Help the pencast to understand better the theory and concepts?

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