Perception and effectiveness of an *eGrade* online tutorial/ assessment scheme in introductory physics courses

Marian W. Radny and
Aime B. Duval
School of Mathematical and Physical Sciences
The University of Newcastle
Callaghan 2308
Australia

phmwr@cc.newcastle.edu.au

Abstract

A computer-aid, online tutorial/assessment scheme based on an *eGrade* (Wiley & Sons) software package designed and implemented in the introductory physics courses at the University of Newcastle (Australia) is described and evaluated. It is shown that the designed approach enhances student's satisfaction and performance, and represents a valuable experience in developing a consistent tutorial/assessment online supporting scheme for large-class introductory physics courses.

Introduction

Ideas and concepts that students develop in introductory physics courses are usually based on lectures and tutorial/laboratory exercises. This traditional instruction scheme is, however, becoming more and more ineffective. This is mainly because of the increased size of classes, lecturers having problems to find the ways of presenting the prescribed content, with some essential topics often left behind as not fitted to the strictly prescribed course syllabus, and due to lack of meaningful class participation by students. Much effort in physics education has thus been devoted to find alternative ways of improving the effectiveness of large class teaching in introductory physics (science) courses. Among many ideas a substantial number of IT software packages has been developed to support the teaching of the lower-level introductory science courses (Schall 1998; Engelmore and Morgan 1998; Lawson 2002). In this paper we focus attention on one of such packages, the *eGrade* online assessment software from John Wiley and Sons (*eGrade* Online Assessment Systems). This online system is an assessment instrument designed mainly to probe a conceptual understating of the topics discussed in introductory science, mathematical and/or computing courses. Typical tutorial physics problems feature, however, specific 'setting and thinking' procedures not generally suitable for existing computer-aid software. We have found, however, that *eGrade* offers a flexible interactive-engagement approach suitable for developing an effective, interactive tutorial/assessment online scheme. In this paper we report on the *eGrade*-based tutorials/assessment scheme developed and implemented at the University of Newcastle (Australia) in 2001-2002.

Design, practice and evaluation

The introductory physics courses offered by the Physics Department at the University of Newcastle (Australia)—Phys1200, Phys1210 and Phys1220—can be characterized as typical service courses. The majority of students in the lower-level Phys1200 course are from the Biomedicine and Biotechnology undergraduate programs, while engineering and science students dominate the two upper-level introductory courses (Phys1210 and Phys1220). As such, the courses have usually a high percentage of unmotivated, poorly prepared students who need frequent practice at mastering basic problem solving skills and techniques, as well as concept development. The traditional approach based on large tutorial classes designed to help students in practicing their knowledge was found to be ineffective. This was mainly due to relentless tendency for the students to regard large tutorial classes as lectures, and lack of student's preparation for the classes. Another adopted system based on small tutorial classes and weekly quizzes, while more effective in achieving the courses objectives, was a highly time and resources consuming effort. Also, due to its very restrictive nature (weekly quizzes), the scheme was not popular among the students. In this paper we describe and evaluate an attempt to substitute the traditional tutorial classes by an online tutorial/assessment homework-type scheme. The main objectives of the proposed approach were to:

- increase lecture participation;
- encourage students to take an active part in tutorials;
- encourage students to interact with the tutor and lecturer;
- encourage students to actively engage with the subject on a regular basis by making the course more prescribed (especially for not well prepared students);
- encourage students to develop skills to critically examine the subject mater and build on their personal confidence in the subject and develop a structured approach to problem solving; and
- encourage students to take responsibility for their own learning and develop skills for independent and individual learning.

The *eGrade* Online Assessment system allows working on assignments over a World Wide Web using web browsers such as *Netscape* or *MS Explorer* and is available for a number of Wiley & Sons textbooks in mathematics, science and computing disciplines. Version 1.0 (adopted in the discussed design) contains also specialised modules such as Calculus Machine to master student's calculus skills such as integration and differentiation. Entering mathematical expressions is also possible. The system accepts a number of different question formats including standard multiple-choice and problem-type questions. In the described design the multiple-choice questions were deliberately avoided. The banks of problem-type questions used in the discussed design was developed on the basis of the Giancoli physics textbook (Giancoli 2000) (prescribed text in the courses) and/or adapted from existing *eGrade* bank based on the Halliday, Resnick and Walker text (Halliday, Resnick and Walker 2001). In the design described here the Calculus Machine was not used and the solutions to the problems provided by the students were of numerical nature only. The remaining details of the designed scheme are:

- an assignment comprising of eight problems based on the discussed lecture material (3 lectures/week) was set up using *eGrade* online software each week;
- two types of problems were assigned for each assignment: six Practice (eGrade Mastery-type carrying a total of 6 marks) and two Test problems (*eGrade* quiz-type, a total of 4 marks);
- problems were the same for all of the students in the course but their numerical content was randomized at every attempt;
- numerical type of answers provided by students (including appropriate units and number of significant figures) were assessed by *eGrade*, not by a tutor or lecturer;
- students had online access to the assignments and scored results (username/password protected) along with access to the lecturer, course coordinator, and course material; and
- two progressive assessment (PA) written tests (middle- and end-semester) were conducted to assessed student's knowledge based on the required pen-and-paper type of the final examination.

In order to effectively encourage students to be actively engaged with the subject the **repeated–attempt**, **immediate–feedback**, **availability** and **work–reward** options were of primary importance to the implemented scheme. Each set of Practice problems was designed to provide a small bank of questions that the students could repeatedly attempt with immediate feedback. In the designed scheme the Practice questions were accessible online with no restrictions (24 hours/day) during the prescribed period (weekly assignments were required to be completed at any time in a sequence of 2-week periods). For Practice problems *eGrade* provided the correct answer every time the question was attempted and submitted for grading. Any success in solving Practice problems was also awarded by appropriate marks (with no penalty for incorrect answers). When working on the Practice questions students were encouraged to work in groups or with a tutor; but they could also do the assignments independently. To help students with their work on the Practice problems and encourage them to participate in discussions with the tutor and/or with fellow students a number of help and computer-laboratory sessions were scheduled during the prescribed period of 2 weeks. During the discussion with the tutor students were guided only towards the solutions (Practice problems) and the detailed answers were not provided. The work on Practice problems was designed to prepare students for their attempt to solve revision type questions – the Test problems. In attempts to solve Test questions no help was provided and students could attempt each question from a test set three times only (the numerical content of the test questions was also randomised at every attempt) after which access to the question was denied. Any success in solving Test problems was also awarded by assigning appropriate marks. After the prescribed period of two weeks the exemplary solutions to the Test questions (with applied the appropriate setting and thinking procedure) were published online. The marks scored from *eGrade* assignments contributed 10% to the final marks in the course (50% for the final examination, 30% for the Laboratory, and 10% for the PA tutorial tests).

Surveys of students and evaluation of their responses were carried out to determine in what ways the designed, *eGrade* based online tutorial/assessment scheme was succeeding (CALT 2001). Figure 1 shows evidence which suggests that students were generally satisfied with the workload and the level of difficulty of the *eGrade* assignments. They also fully adopted the availability option as most of them worked on their weekly assignment individually, at home. We have noticed that awarding some marks for any successful attempt in solving Practice problems appeared to be a very effective way to encourage students to work consistently on their homework assignments. On the other hand the students responses indicate that the evaluation of knowledge of the subject confronted with their ability to perform satisfactorily in the mid- and end-semester written PA test (and consequently in the final examination) was rather a controversial issue. Figure 2 illustrates the performance of similar groups of students in their written pre-*eGrade* and post-*eGrade* mid-semester PA tests conducted in 2000 and 2001, respectively. As can be seen from the data there is a clear difference in the distribution of marks between these two groups of students with lower marks allocated to the students practicing the *eGrade* online tutorials. The primary reason for this was the fact that the students were assessed using a pen-and-paper type of assessment while their preparation based on *eGrade* assignments did not provide this type of training. They were

also not satisfied with the way in which the help was made available. It appeared that the computer-based help session favoured a tutor–student face-to-face discussion rather than a group discussion. This situation made a tutor practically unavailable for many students in the class during the prescribed one hour help session period. As a result they looked for help somewhere else (fellow students or the textbook). Surprisingly, students did not regard the course lecturers as a valuable source of help when working on *eGrade* Practice assignments. Finally, we would like to point out that any errors and mistakes in coded solutions to the assigned problems resulted in students losing confidence in the scheme and unstoppable claims that the provided solutions were wrong even when that was not the case. If this happens repeatedly, it may have a devastating effect on the proposed design because students then fail to question their solutions and learn from the process.

Based on the above observations, the following changes were introduced to the scheme and implemented in the same introductory physics courses offered a year later:

- weekly lecturer-student consultations were established in order to involve the lecturing staff in assisting students in practicing their knowledge using *eGrade*; also to ensure that students see the link between the lectures and assigned problems the lecturers were encouraged to include *eGrade*-like working exercises in their lectures and lecture notes;
- computer-laboratory help sessions were replaced by 'background sessions' (outside the computer laboratory) where problems similar to those assigned in *eGrade* were discussed by the tutor (applying the appropriate setting and thinking procedure);
- to retain a focus on structured problem solving (setting and thinking) multiple, sequential answers to the problems were introduced to *eGrade* assignments; partial credit was also given to account for the fact that an incomplete answer may demonstrate the achievement of some learning outcomes;
- students were given eight days to do the questions; this removed the problem with many students leaving their assignment until the last minute and ensured that the students completed the assignment before the next sequence of three lectures; and
- the requirement for the correct number of significant figures in the provided numerical answers was removed.

After implementing these changes the improvement in scored *eGrade* marks has been found to increase by approximately 18% from the previous scheme score, still however approximately 15% less than the marks scored from the pre-*eGrade* written test. Results of evaluation of student's responses to the improved design are presented in Figure 3 (CALT 2002). The data presented on this figure clearly shows that a great majority of students supported the revised online tutorial/assessment scheme.

Conclusions

A computer-aid, online tutorial/assessment scheme based on an *eGrade* software package has been described and evaluated. The results show that the designed online tutorial system enhanced students' satisfaction and their performance in a pen-and-paper type of assessment can be regarded as satisfactory. Despite the evident improvement in both student's satisfaction and performance in the courses supported by *eGrade*-based online tutorial/assessment scheme, some of the course lecturers had reservations about the use of *eGrade* in our introductory physics courses. They argued that students who had (no) little understanding of 'setting and thinking" procedure characteristic for solving problem in physics, had (no) little understanding of the subject matter. The results presented in this paper show, however, that the described design based on *eGrade*, while not yet an alternative for the traditional tutorial delivery/assessment system, represents a valuable experience in an attempt to develop a consistent, integrated online tutorial/assessment supporting scheme for large-class introductory physics (science) courses.

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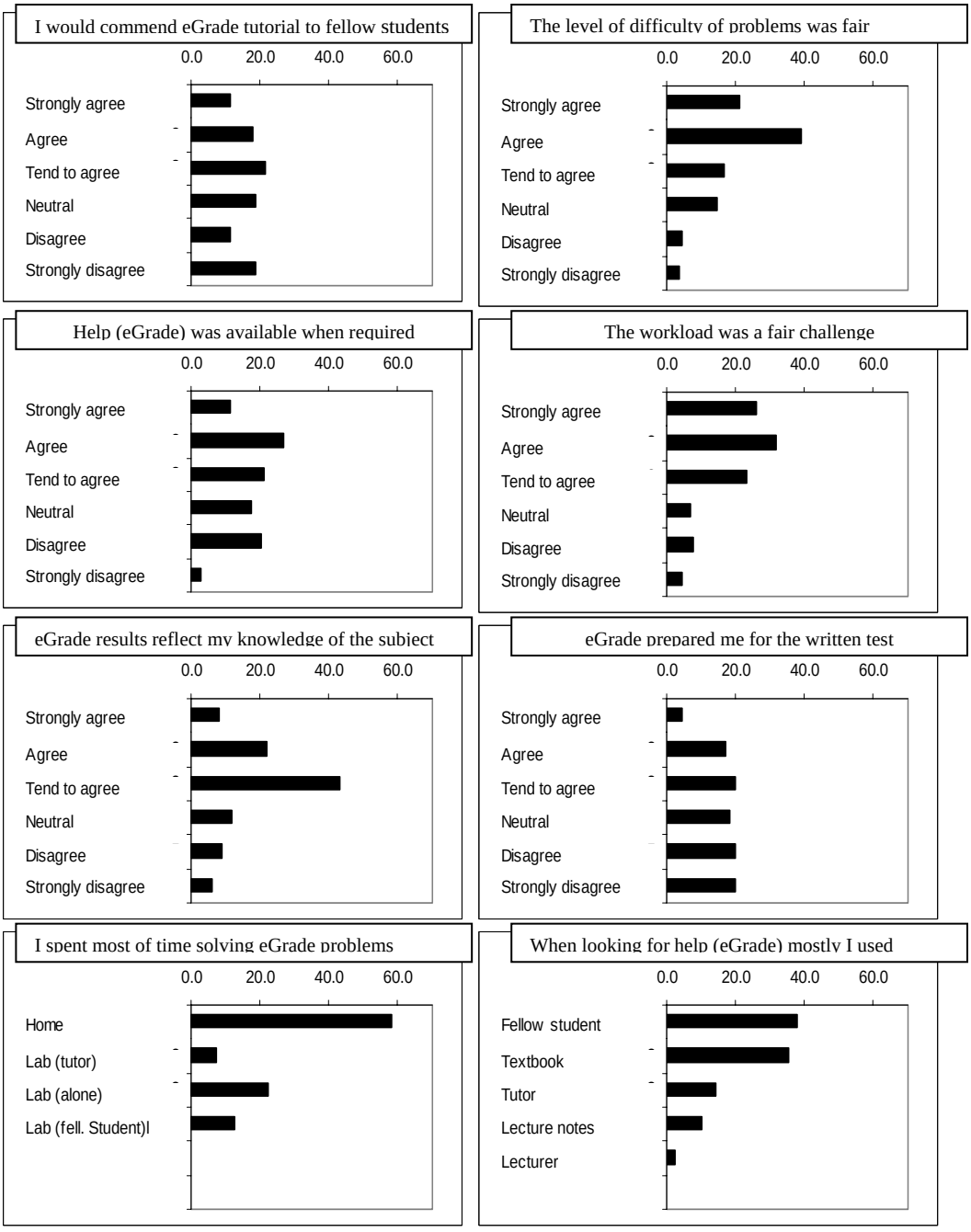

Figure 1. The percentage of students responding to the end-semester evaluation questions regarding the *eGrade* online tutorial/assessment scheme at the University of Newcastle (Australia)

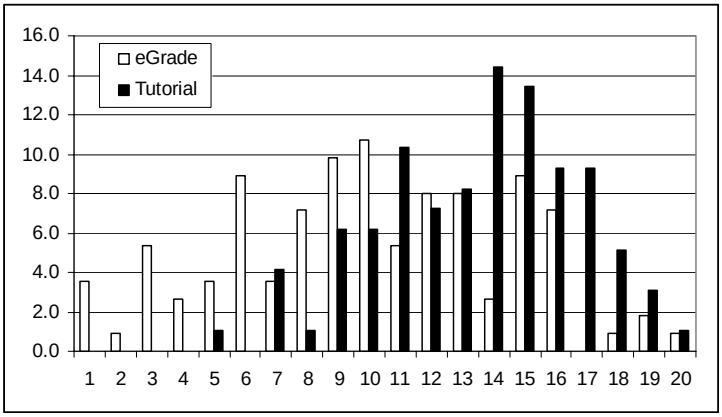

Figure 2. The percentage distribution of pre-*eGrade* (solid bars) and post-*eGrade* (empty bars) of student's marks (0-20) from a mid-semester written test

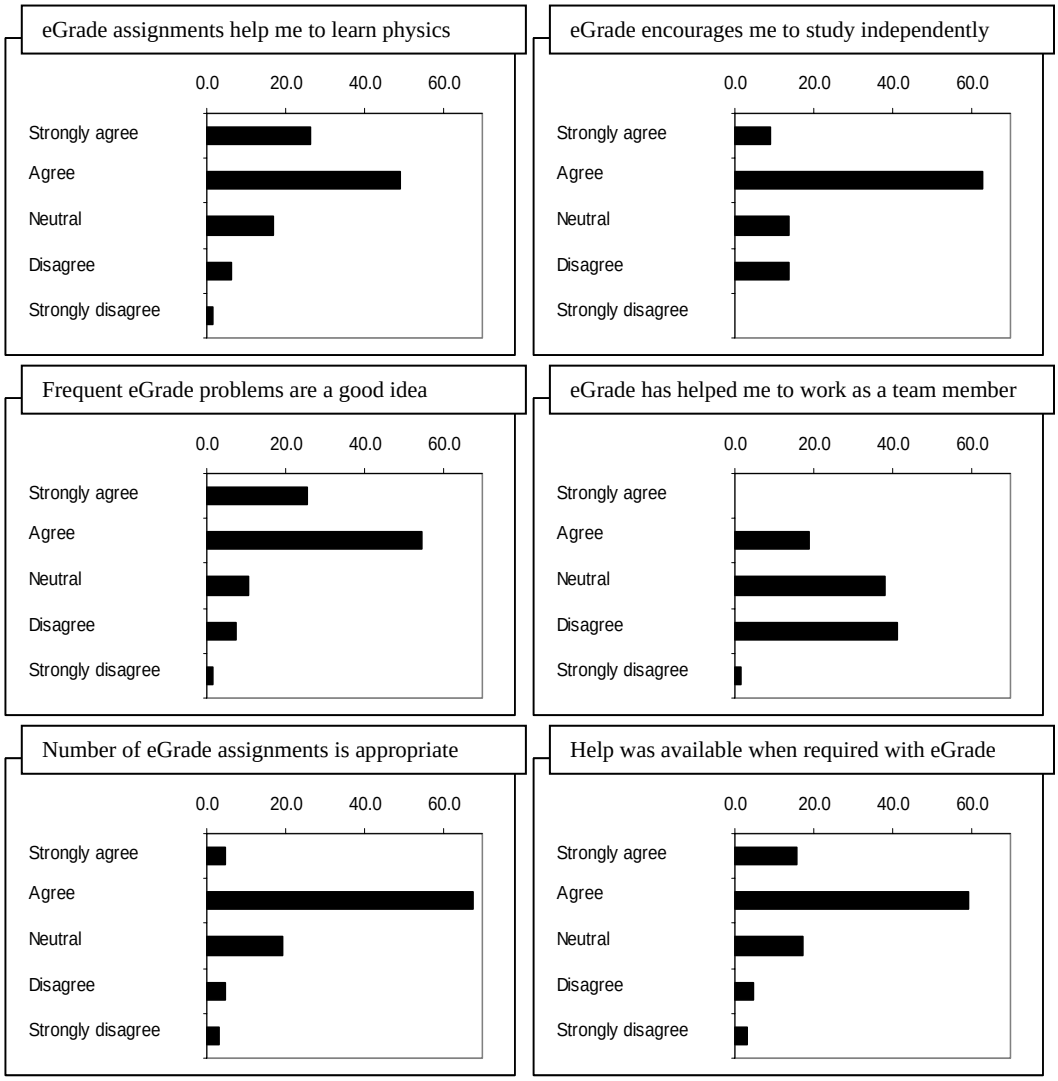

Figure 3. The percentage of students responding to the end-semester evaluation questions regarding the improved *eGrade* online tutorial/assessment scheme at the University of Newcastle (Australia)