Developing Web-oriented Homework System to Assess Students' Introductory Physics Course Performance and Compare to Paper-based Peer Homework

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ABSTRACT

The World Wide Web influences education and our lives in many ways. Nowadays, Web-based homework has been becoming widespread practice in physics courses and some other courses as well. Although are some disputes whether this is an encouraging or risky development for student learning, there is limited research assessing the pedagogical effect of changing the medium from written, hand-graded homework to online oriented, computer-graded homework. In this study, web-oriented homework system is developed to assess students' introductory physics course performance. Later on, these results are compared with paper-based (peer) homework performance for mid enrollment physics courses. One of two identical sections of introductory physics course students received paper-based, hand graded group homework while the other received the individual web-based homework. Then two groups' on conceptual and problem-solving performance measures are compared. No significant differences were found in students' Force Concept Inventory (FCI) test scores; however, average homework performance scores were significant that could be attributed to the homework method used in favor of paper-based peer homework group.

Keywords: Physics assessment; web-based homework; paper-based homework; FCI.

INTRODUCTION

The World Wide Web is affecting education as well as our lives in many ways. So far, the major use of the www in teaching has been for finding and distributing information, much like an online library. However, as information technology evolves, the Web has been increasingly used for more interactive applications such as online homework and online testing probably most rapidly growing educational uses of the Internet. Self-assessment of web submitted homework and hand-graded homework of peer assessment refer to those activities of learners in which they judge and evaluate their own products of work and those of their peers with similar learning backgrounds. Both types of assessment emphasize students' active participation in the evaluation process. The two assessment methods are rapidly becoming more pervasive and dominant (Paris & Paris, 2001; Shepard, 2000).

In conventional classroom assessments, teachers usually play a major role. In contrast, self- and peer-assessments require that students execute the assessment of their learning results and those of their counterparts. These processes have been demonstrated to produce beneficial effects in the cognitive, meta-cognitive and affective aspects of students' learning (Falchikov & Boud, 1989; Topping, 1998).

Although, several dated review articles have summarized studies of the relationship between homework and academic performance and homework in general has been appreciated as an important course element (Cooper, 1989; Keith, 1982; Paschal, Weinstein, & Walberg, 1984). One review that examined 15 quantitative studies (Paschal, Weinstein, & Walberg, 1984)

concluded that there is a moderately large positive effect of homework on achievement, especially homework that teachers grade or write comments on it. Another review (Cooper, 1989) examined 120 studies of the effect of homework on achievement. Twenty of the studies compared the achievement of students (in grades 1-12) who were given homework assignments with students who were not. Cooper also reviewed 50 studies that correlated achievement with the amount of time students reported spending on homework, and found that in 43 studies (or 86%), a positive correlation was found indicating that students who spent more time on homework received better grades; the remaining 7 studies indicated the opposite. As in the previous homework/no-homework comparison, the effect was nonexistent for elementary school students, and largest for high school students. A positive correlation between time spent on homework and grades was also reported in a study of high achieving high school students (Tymms & Fitzgibbon, 1992).

Electronic homework as a course element has even more positive effects than written homework affirm by some researchers (Dufrense et al., 2002; Ogilve, 2000; Thoennessen and Harrison, 1996). Dufrense et al. (2002) for example compared the effect of the electronic homework and the written homework on student achievement as measured by exam performance. They found both that electronic homework led to higher overall exam performance. Nevertheless, the study conducted by Bonham et al. (2001, 2003) found that no significant differences in student performance were found that could be attributed to the homework method used.

THE CONSTRAINTS OF PAPER-BASED ASSESSMENT

Using paper-based methods have some constraints. The possible constraints to paper-based assessments may be compensated by technology:

The first constraint is that there is a relative problem of displaying multimedia works using pens and paper. However, in a computer-programmed environment, text, sound and graphics are just a few types of input that may be accessible in the web-based environment.

Secondly, computers could make possible the effectiveness in recording and compiling the results of scoring/commentary. In scoring or providing commentary of the works using pen and paper, limitations become obvious when multiple objects of assessment are dealt with (Billington, 1997; Hughes & Large, 1993). Further, as it is difficult to make real-time compilations and summaries of the scoring results, students may have difficulty in getting immediate feedback on their personal scoring results or in having, the general picture right after the scoring activity is completed. With offering database technology, when incorporated with an appropriate user interface, could provide instructors and students with efficient tools for recording. In addition, coupled with appropriate computation functions, it can even do speedy calculations as well as make quick summaries and presentations of the records of assessment to provide users immediate feedback.

Thirdly, web-technology could provide students with more opportunities of peer interaction beyond the constraints from time and locations. The essence of self- and peer-assessment lies in personal interactions. However, given the limited time of a class, even finishing the assessment activities itself poses a challenge; little time is left for discussion. The web-based environment is characterized by its accessibility at any time and its provision of synchronous and asynchronous methods of communication; therefore, it is possible to conduct activities either within the classroom or in after-class situations.

Fourthly, it can be increased the diversity of teachers' implementation of self- and peer-assessment. A remarkable variety of forms of implementing self- or peer-assessment is

possible. In setting the standards of scoring, for example, there are the options of letting the instructor set the standards (e.g., Magin & Helmore, 2001) or allowing students to do it themselves (e.g., Orsmond, Merry, & Reiling, 2000).

METHODS OF WEB-BASED TESTING

Testing is used for two essential purposes: to provide feedback and evaluation. Feedback refers to the response regarding a critical analysis of students' work. Evaluation refers to the grading and recording of students' work for assessing their understanding of material. These two purposes are not mutually exclusive. A testing instrument, whether it is a homework assignment, quiz, exam, or practice test, can satisfy both purposes to a varying degree. For instance, a practice test is primarily used to provide feedback to students for their self-evaluation. On the other extreme, an exam is primarily used for evaluation. Evaluation and feedback have different goals and thus have different implementation requirements. Because evaluation is primarily used to record student responses and assign grades, security concerns such as verifying a student's identity, protecting answer keys, limiting access according to a specific time or location, and preventing unauthorized sharing of information need to be considered. The second use, feedback, is used to respond to students' input by providing "correct/incorrect" responses, hints, and solutions or by engaging the student in additional learning activities much like present computerized tutorials.

POSITIVE CHARACTERISTICS OF WEB-BASED HOMEWORK ASSESSMENT SYSTEM

The positive sides of automated web-based homework assessment system could be summarized as follows (Titus et al., 1998):

Pedagogical approaches

Using automated submission and scoring of assignments, instructors can give students more frequent assignments and more questions on each assignment than is possible with traditional methods, thus increasing the time that students spend studying material, answering questions, and solving problems. In fact, the computer can control the path through the assignment if desired, making the better prepared student's progress more efficient while choosing a more gradual approach for the less able student. Using Web-based assessment, similar questioning techniques can easily be administered to a large number of students. Even when assignments are more for self-evaluation and practice than for formal testing, records can be made of time on task and correlated with success in the course. Reports of this information to future students can make using the Web-based assignments more edible.

Reducing administrative effort

Increasing students' time on task and continually administering homework is made possible by automated grading. The server takes over the tedious grading of papers, which is often the obstacle to assigning more frequent homework or quizzes. It saves grading time for the instructor (or hired graders) and improves the quality of class time spent in problem solving recitations. Automated scoring also allows the instructor to perform item analysis to determine which questions are best predictors of student performance. Instructors can then fit their assignments, whether homework, quizzes, or exams, to include questions that are best for probing student understanding.

Instantaneous feedback

With computer-aided assessment, students can receive immediate feedback about their progress. Surveys given to students indicate that immediate feedback is one of the most appreciated aspects of web-based assessment. For this reason, it is valuable to deliver

assignments with immediate feedback and assignments with delayed feedback. The former type encourages students to consider why they missed certain questions and the latter ensures that students fully consider their answers before submitting.

NEGATIVE CHARACTERISTICS OF WEB-BASED HOMEWORK ASSESSMENT SYSTEM

Web-based assessment can be effectively used for providing unbiased evaluation and feedback on a frequent basis that is immediate, platform independent, multimedia-enhanced, and automated. However, new technology brings new concerns. The negative sides of automated web-based homework assessment system could be summarized as follows (Titus et al., 1998):

Failure of observing students works

When grading, it is useful for physics instructors to view students' work, check their diagrams, and follow their reasoning. Unfortunately, this is not currently possible on the web. As grading becomes automated, the instructor may lose students' some perception into the problem solving processes. This may be the largest restriction to Web-based assessment when used for evaluation.

Less diversity of questions and grading methods

Automating the grading process eliminates certain types of questioning and grading. Yet, there are new types of questions that can be delivered on-line that cannot be delivered on a piece of paper.

Security issues

If the web is used for evaluation, security issues inevitably arise. How can the instructor be assured that a student is doing his or her own work? In the case of homework, the grade is not heavily weighted, students are usually expected to work together, and password verification may be enough to deter less-motivated cheaters. For exams or quizzes, security is a vital issue since these elements often count for a large part of a course grade. In this case, there are sufficient ways of insuring security. One such way is to use randomization. Numbers within questions or the order of choices in multiple-choice questions can be randomized.

Technical difficulties

When using the web for assessment, instructors must realize that technical problems could occur. For instance, the server may be down or server software may need to be updated. Instructors must plan to handle these difficulties, and it must be clear to students what they should do in the inevitable event of a technical problem.

Typically, it is sufficient to extend the assignment deadline for individual students who have such trouble. Students also need access to the internet. At this time, it is unreasonable to assume that every student owns a computer and has internet access from home. Therefore, a school should have computer labs where students can access the internet on a regular basis.

PURPOSE AND RESEARCH QUESTIONS

The main aim of this study is to develop web oriented, computer-graded homework system to assess students' introductory general physics-1 course homework performance and conceptual understanding and to compare these findings with the result of paper-based peer homework group. Meanwhile, the following research questions will be posed:

- **Is there any statistically significant difference between assigned groups' FCI pre- and posttest scores?**
- **Is there any statistically significant difference between assigned groups' homework performance scores?**

METHODOLOGY

Participants

The participants for this study had chosen a sample of convenience from Computer Education department (They have many experiences about online and computer-based assessment). In an introductory physics course, students were taught by peer instruction. Web-based homework group consisted of 41 students and paper-based homework group consisted of 37 students.

Study design and Procedures

A two-group pretest–posttest design was used in this study. This is a quasi-experimental design in which one group is subjected to a treatment and the other is subjected to a control group (Fraenkel & Wallen, 1996). Students were registered for the two different sections through standard course registration system and were unaware of the homework method until it was announced at the first week of physics-1 class. The physics-1 course has two main exams, one of which is mid-term and the other is final exam. The homework performance scores in both groups were added to include the 20 % of the final grade of the course. One (experimental group) is received their homework via online quiz system where it was graded by computer. The other (control group) wrote out solutions to homework exercises on paper with working as a group consisted of four or five students. These exercises were turned in and graded by the instructor. Throughout the semester after each unit of physics-1 course was completed; students were administered homework questions according to their assigned groups. Most of the homework exercises on which the two groups worked was the same or similar problems from the physics textbook (Turkish translation of Principals of Physics by Bueche and Jerde, sixth edition, 1995) with addition of some conceptual questions by the instructor. There were total eight homework exercises, in both groups, they were graded in percentage scores, and average scores calculated to be used as their homework performance scores. The Force Concept Inventory test was administered before (in first week of the semester) and after the instruction (the last second week of the semester) in both groups. FCI test scores (in percent average scores) and homework performance scores were then taken to SPSS packet programme to make necessary analyses.

Web-based and paper-based peer homework groups

Paper-based peer homework group consisted of four or five students each group and there were 37 students in total. The types of problems used in group homework assignments are nearly identical to those used in individual web-based homework assignments; in fact, the vast majority of the problems in the web based homework library come from the chapter problems of standard first year university algebra-based physics textbooks with addition to some conceptual questions. After finishing every unit -there were nine units-, students were given one assignment of five to nine problems.

Gibson (2001) et al. suggested that the online testing should be one component of the evaluation of the student; therefore, in both systems 20% of the course final grade comes from the average homework score. The web-based homework system is called "online testing" and detailed description of the program is explained in the following section.

The structure of the Web-based homework system

The Web-based homework system was developed by Linux-based php extension html environment with using MySQL database system and has two main modules. The first module is for students and the second is for instructor.
The system's main goals are:

- **To provide instruction with a simple and easy online interface to create and manage online multiple choice and subjective exams, with such features as automatic grading, and feedback to students,**
- **To let instructors and students check grades.**

In students' module, as shown in Figs. 1a, b and 2, first, students have to register to password protected web-based homework system. Once they enter the system whenever their homework are activated to ready for take it, they colud only see and able to take their test. After finishing the test, they could see their results from the test to get immediately feedback from it. Students may ask any question related to test or any problem that encountered any time just clicking provided link to communicate their instructor (Figure 3) to write e-mail messages. Then also, students could be able to see any time their homework results by clicking related link (Figure 4).

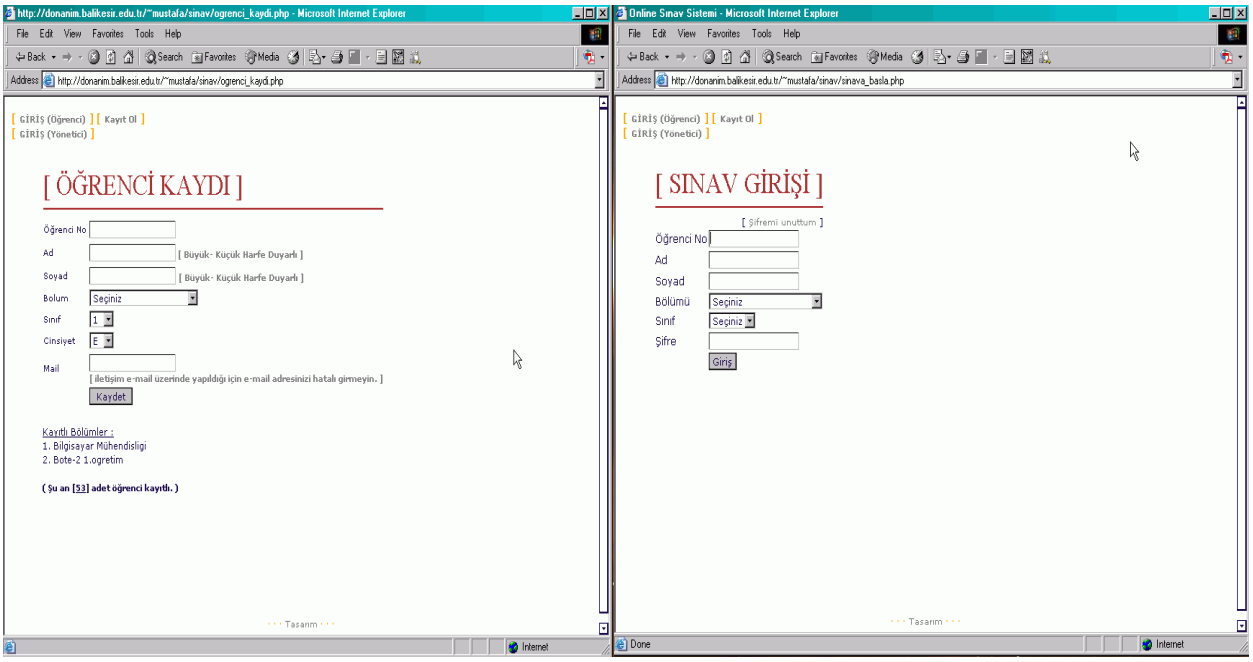

Figure:1a and 1b
Students' registration and logging in online homework system pages, respectively.

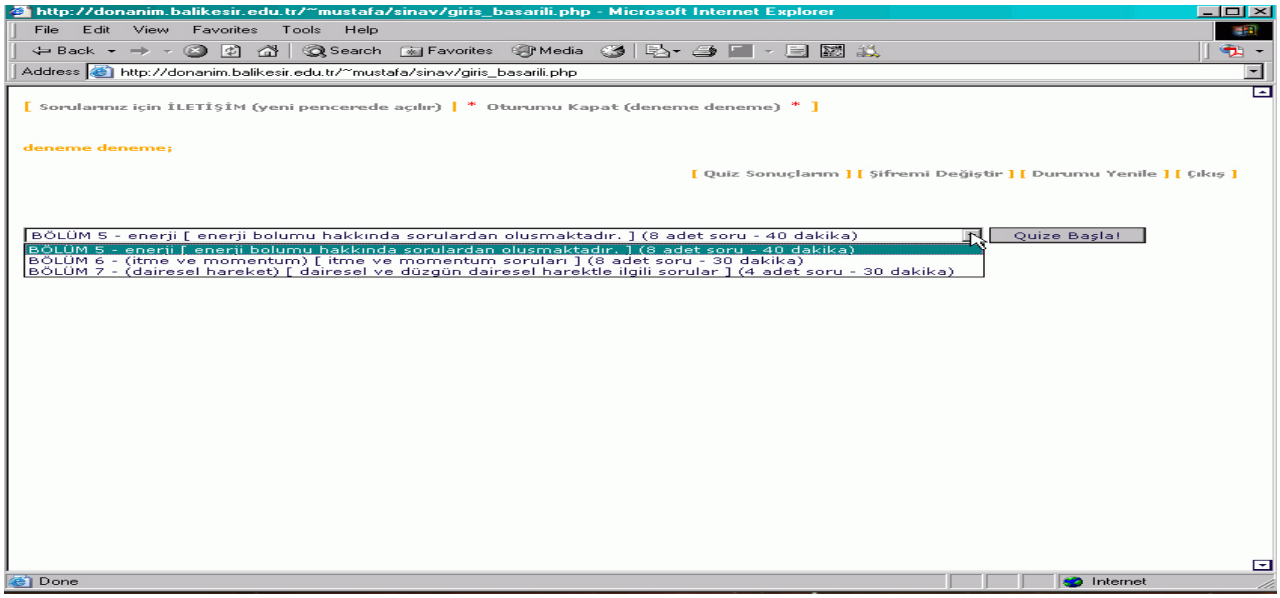

Figure: 2
Ready to take some "online quizzes" by students

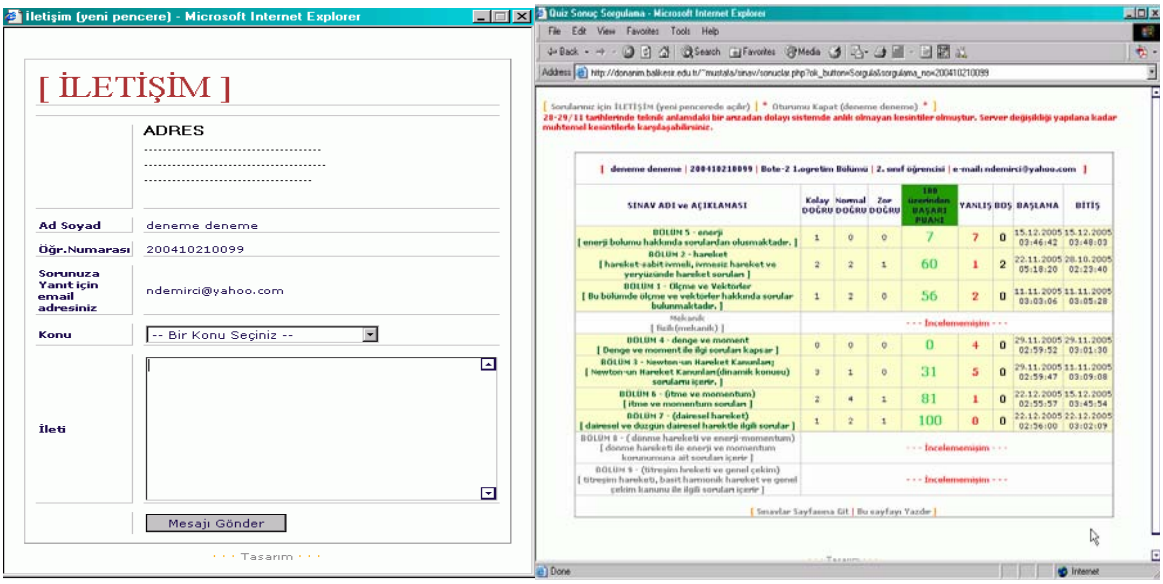

Figure: 3 and 4
Students' communication to the instructor and students' sample homework result' page, respectively.

The instructor management module provides instructor with a convenient user interface that allows them to execute various setup and management functions online, such as setting up accounts, setting up test parameters, queries as to students' scoring process and observing various assessment results at any time. Web-based homework system offers parameters for instructor to configure the options of various types of activities (Sample activities are shown Figs. 5 to 10).

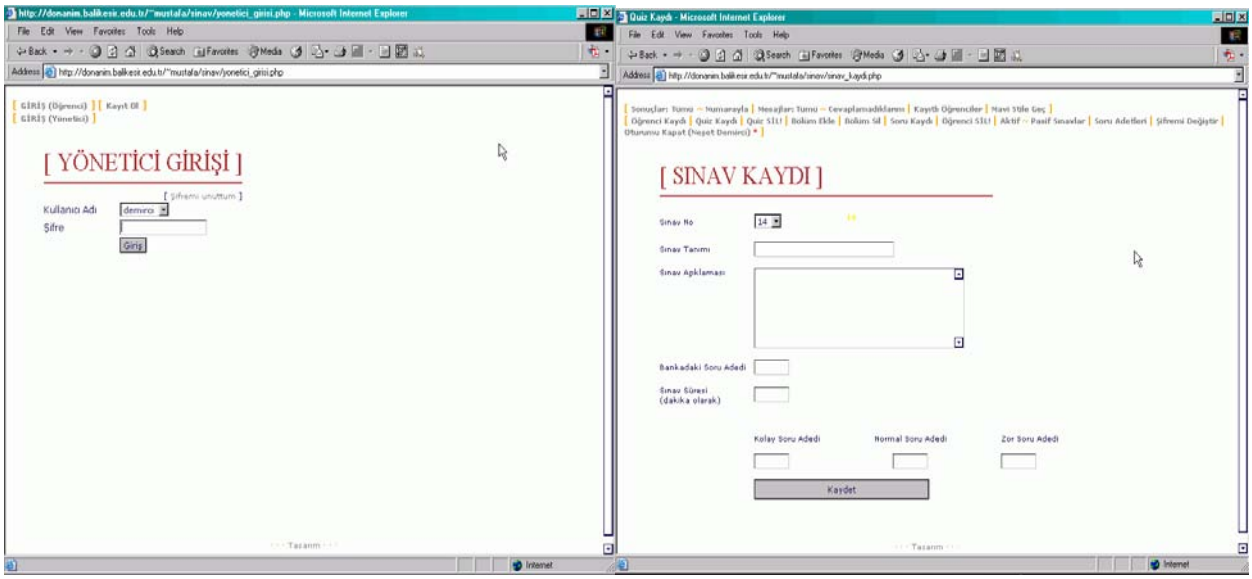

Figure: 5 and 6
Instructor's entrance page and homework quiz recording page, respectively

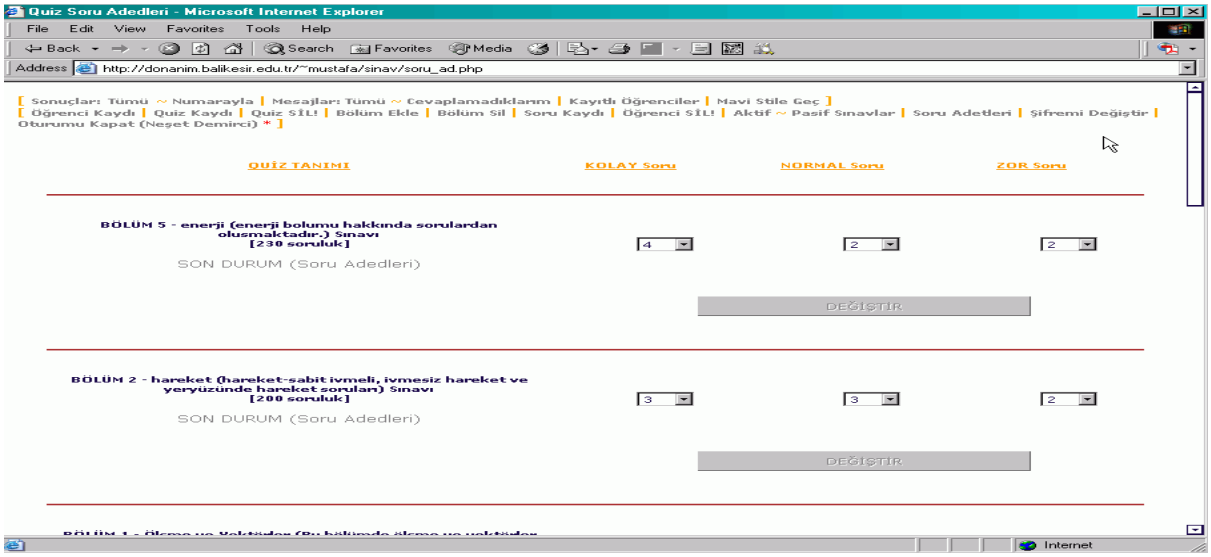

Figure: 7
Defining number of homework questions for any quiz

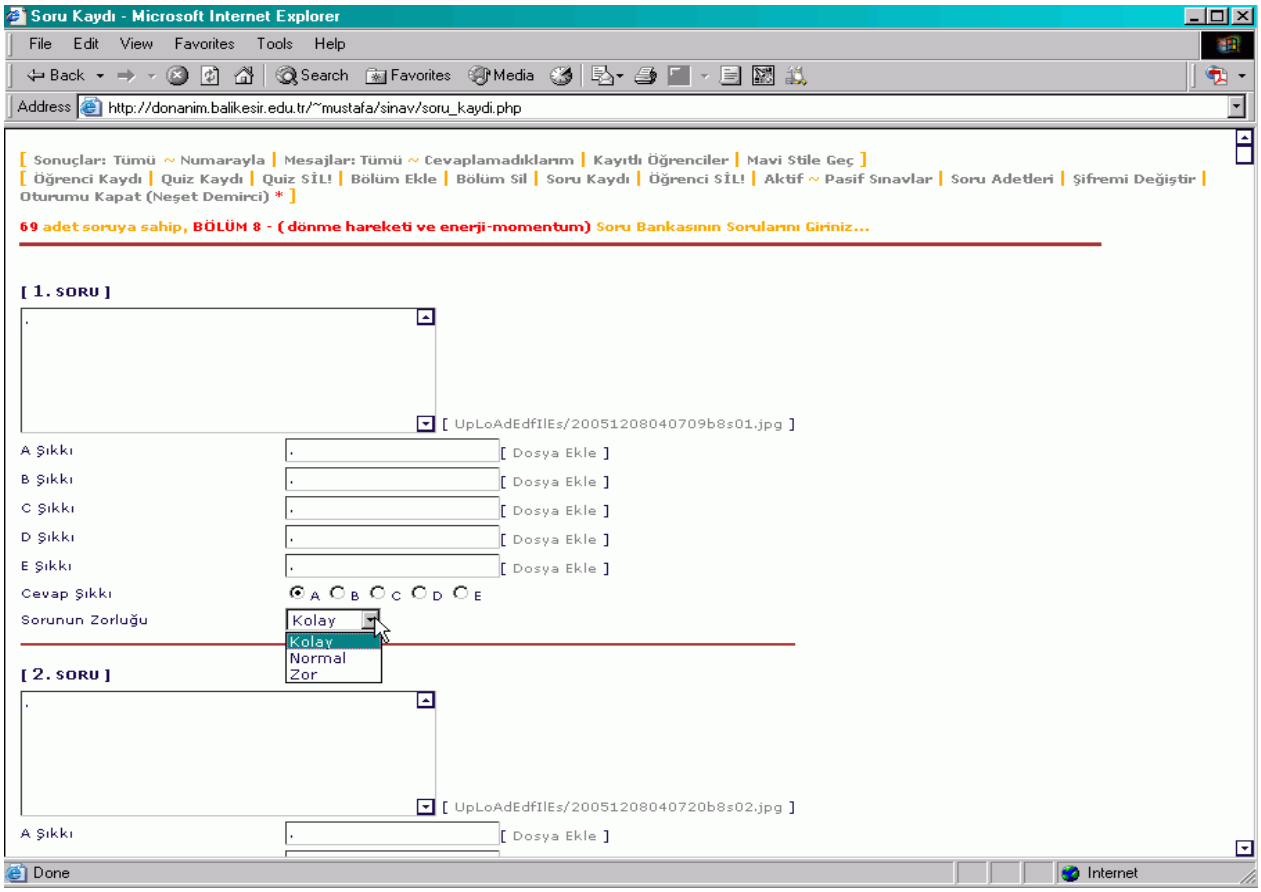

Figure: 8
Entering homework questions according to its unit and defining correct answer and level of difficulty.

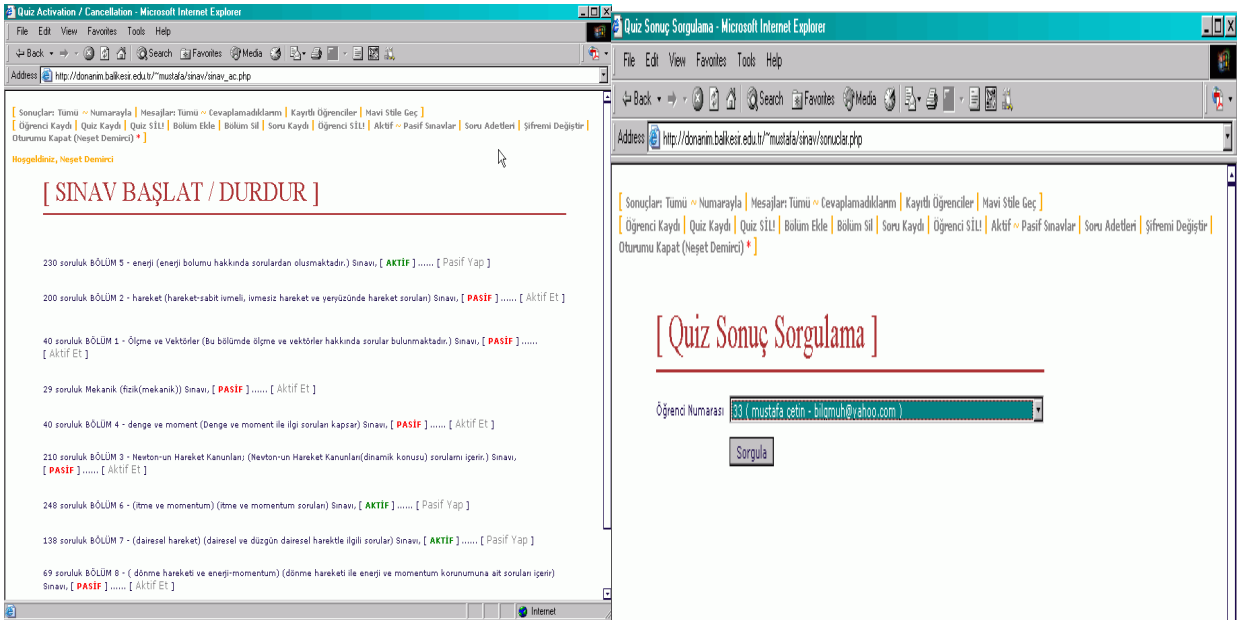

Figure: 9 and 10
Activating / Deactivating quizzes, and students' results pages, respectively.

By the instructor module, the instructor might do the following main tasks:

- **Create or delete homework assignment quizzes and define number of questions to be asked for each assignment.**
- **To see students' homework results and progress, and see their detail of assignment results such as starting and finishing date and time, etc.**
- **Answer students' e-mail messages to communicate with them to solve whatever problems they might have encountered during the process.**
- **Able to activate or deactivate any particular assignment to students.**
- **Define number of questions for each assignment.**
- **Define the level of difficulties of those questions which uploaded the server (specifically in cognitive knowledge and conceptual questions labeled as "easy", questions in application level labeled as "normal"; questions in complex application and analysis level labeled as "difficult". see figure 8).**

RESULTS AND DISCUSSIONS

This part consists of two sections, descriptive statistics, and inferential statistics.

Descriptive Statistics

The results of homework performance scores (in percentage), FCI pre-, and posttest scores, and normalized-gain scores for both groups are given in Table: 1.

Table: 1
The results of both groups' FCI tests and homework performance (percentage) scores

	Web-based homework-group			Paper-based homework group		
	N	Average	S. Deviation	N	Average	S. Deviation
Homework performance	41	71.15	15.428	37	80.30	7.237
FCI pre-test	40	41.05	11.89	33	42.73	9.69
FCI post-test	39	62.87	9.96	36	61.44	9.97
FCInormalized gain		%37.01			%32.66	

It can be seen in Table 1 that average FCI pretest score (in percentage) in both groups are about in the forties and posttest scores are about in sixties, however homework performance percent score for web-based group are about 71%, while for paper-based group are about 80 %. Moreover, web-based homework group's FCI normalized gain score is about 37 %, the paper-based homework group's gain score found about 32.6 %.

Inferential Statistics

Both homework assignment groups' summary t-test results related to FCI pre- and post-test scores and homework performance scores are given in Table: 2.

Table: 2
T-test summary results

Test differences between groups	df	t-test	p
Homework performance differences	76	-3.29	0.002*
FCI pre-test differences	71	-0.65	0.517
FCI post-test differences	73	0.61	0.539

*p<0.05

It can be seen in Table 2 that there were not any statistical differences in FCI pre- and posttest scores in terms of assigned groups of being web-based or paper-based (t_{71}=-0.65, p>0.05 for FCI pretest; t_{73}=0.61, p>0.05 for FCI posttest). However, statistical difference is found in favor of paper-based homework group in average homework performance scores with respect to assigned two groups (t_{76}=-3.29, p<0.05). Average normalized gain percentage score of web-based group is higher than paper-based group's score, on the contrary, paper-based assignment group's average homework performance percent score is higher than those of web-based group are. This result is also not statistically significant at the 0.05 level as well. It is remarkable that although computers or web-based homework system may have advantages of supporting conceptual understanding (with higher FCI gain scores), these advantages could not continue in their homework performance score. Moreover, significant differences found in this study between web-based and paper-based homework groups shows that solving homework problems with peer groups could be effective than web-based homework system.

CONCLUSION AND IMPLICATIONS

Was the web-based testing effective on students' physics homework performance score and conceptual test (FCI) achievement score when compared to paper-based homework? There was a not statistically significant difference between web-based homework system and paper-based group homework system with respect to conceptual FCI pre- and posttest scores. However, Ogilve (2001) concluded that electronic homework tutoring led in producing gains in FCI score that were twice as large as those from the written problem set were. While comparison of their performances on regular exams, conceptual exams, quizzes, laboratory, and homework showed no significant differences between groups; other measures were found to be strong predictors of performance(Bonham at al., 2003), however, in this study, there was a statistically significant result between web-based and paper-based homework assignment results in favor of paper-based group. Dufresne, Mestre, Hart, and Rath, (2002) compared student performance over several years in large introductory physics courses, including both calculus-based and algebra-based courses, and four different instructors who had taught courses with both paper-based and web-based homework system. Student exam scores generally improved at a significant level after the introduction of web-based homework. Students using web-based homework reported spending significantly more time on assignments than did those using paper homework. The paper-based homework groups' students were required to work out the entire solution and show their work, whereas the Web-based homework groups' students needed only to submit the final numerical answer.

The current literature does not really answer questions raised if computerized homework or web-based is more effective or otherwise around. Homework is important for technical courses such as introductory physics, where problem solving is a major focus and homework is the main venue for practicing. Although, Maloney (1994) claims that many students struggle to develop problem-solving skills in physics, it has been shown that directed instruction and feedback are effective in developing problem solving skills (Heller & Reif, 1984; Heller & Hollabaugh, 1992).

It has been argued that learning environments are more effective for collaborative learning, and in this study collaboration of paper-based group was found to be a significant factor related to average homework performance scores. This could be because of the presence of certain behavioral factors that can have significant effects on relationships between performances. For future study, it would be fruitful to examine such behaviors in relation to other factors associated with learning, such as learning styles, attitudes, environmental variables, and learning strategies and methods. Additional contextual factors should be

considered, to include students' extra-curricular activities. Such inquiries could prove to be some beneficial results (Kotas and Finck, 2002).

Web-based homework is a viable alternative to the traditional paper-based approach. It does not bring significantly greater benefits to students, but neither does it do much worse than standard methods of collecting and grading homework. This supports the viewpoint that technology itself does not improve or harm student learning, but somewhat the underlying pedagogy is the vital issue. Automated homework system probably will help students in courses where homework could not otherwise be assigned. Students generally respond positively to using a computer for homework.

Web-based homework may also allow for more pedagogically sound instruction by freeing up instructor resources for other aspects of the course, or by enabling new kinds of assignments that may be more valuable than traditional paper-based ones. Technology alone is not going to improve instruction, but web-based homework has a fair place in the physics instructor's toolbox.

Self- and peer-assessments are methods of evaluation highly recommended by researchers, but the traditional pen-and-paper-based self- and peer-assessment method has many restrictions (Sung et al., 2005). Replacement of hand-graded homework by computer work could improve student learning by freeing time and economic resources for more effective instructional methods, and could be a medium that allows widespread use of exercises with greater pedagogical value (Bonham et al., 2003).

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