Exploring an Alternative to the Traditional Lecture
The Web-Lecture - A Technological Solution with Numerous Benefits

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Abstract

By using innovative computer software and the Internet, we produced a web-based alternative to the traditional college astronomy lecture - a web-lecture[2]. Using a professor's scheduled lecture time differently than in traditional courses, we tested the approach to see if students gained similar knowledge, tools, and practice in solving problems. Along with this technology, we examined the effect on student learning of participation in an "active" or a "passive" review sections following the web-lecture. The project was implemented in a 100-level astronomy course at the University of Wisconsin - Madison. The software used to create the web-lecture (eTEACH), enable simultaneous and synchronized presentation of video, audio, and slides, and offers additional technological advantages to the benefit of both the students and the professor. The project had 3 phases: I) a test taken before the web-lecture, probing understanding of 3 key concepts (pre-test), II) the web-lecture, and III) review sections where students were split between active and passive learning environments, and a post-test (same questions as pre-test) was given at the end. From student self-assessments and from our own assessment of student learning using the pre- and post-test scores, we conclude that students made significant gains in their understanding of the key concepts taught in the web-lecture and in the review section, independent of the learning environment. We also conclude that overall, students participating in the active learning environment experienced significantly higher gains in their understanding of key concepts over those in the passive review sections. Student assessments of the format and quality of the web-lecture and of the technology used were positive, and their feedback provides helpful guidance for improvements for future projects and implementations.

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[1] A graduate student at University of Wisconsin – Madison, Department of Astronomy, when carrying out the project described in this paper.
[2] To see the web-lecture discussed in this paper go to:
http://eteachb.engr.wisc.edu/Meibom/ESPP_eTEACH_3/eteach_player.html

Introduction

Educational research finds that students learn best in environments with a strong emphasis on teamwork, discussion, problem solving, and hands-on experience [see e.g. 1,2,3,4,5,6,7 and references therein]. Even so, the recognition of the need for such active and discovery-based learning environments has outpaced the changes implemented by colleges and universities to meet that need [e.g. 8]. The dominant form of teaching in American higher education is the traditional lecture in which the professor delivers instruction in a scheduled period of time. In the lecture hall, the combination of physical layout (bolted down rows of chairs), large classes, and limited time, prevents sufficient interaction between the students and the professor to foster an active learning environment. As such, the lecture is a lost opportunity for the students to learn from their professor and for the professor to learn about the level of understanding from a diverse student body. The many reasons for the persistence of the traditional lecture-hall lecture is beyond the scope of this paper, but among them is the lack of a viable alternative for the professor to give the students the basic knowledge and tools they need to solve problems and learn.

Today, technology in the form of computer hardware and software and the Internet, offer an attractive alternative to the lecture format, and to the way teachers teach and students gather information and learn. Computers and the Internet can help professors make better use of their scheduled time with the students, while still providing them with the necessary background knowledge and introduce them to key concepts. In fact, innovative software offer an increasing number of technological advantages that can make learning more effective and fun, and that can accommodate a breath of learning styles and speeds, including those of students with special needs. At the same time, access to computers and the Internet through schools and colleges or at home, have made both students and teachers more proficient with their use. Indeed, future generations of college students will be accustomed, from their K-12 and high school educations, to the innovative use of such technology to create flexible learning environments.

So motivated, we engaged in a project to explore an innovative alternative to the traditional college lecture using modern computer technology and the Internet. Specifically, our goals were to test a technological innovation that can: **1)** Enable professors to engage the students in an active learning environment that introduces them to teamwork, real-world problems, and the excitement of scientific discovery. **2)** Provide the students with the knowledge and tools they need to participate in such a learning environment and learn. **3)** Accommodate diversity in the student body, such as differences in learning styles and speeds, and the special needs of disabled students.

In this paper we list the specific learning goals and objectives and give a description of the project technology. We describe the concept of a *web learning-module* and the technological advantages to both the professor and the students. The project had a 3-phase structure with an emphasis on measuring the net student learning and the effect of the learning environment. We describe all 3 phases and present the results of the students' evaluations of the web learning-module, their learning self-assessments, and our assessment of how well they learned the key concepts taught. We end with a look back at the lessons we learned and forward to our plans for improvements, re-implementation, and new ideas.

The Extra-Solar Planet Project

The Extra-Solar Planet Project (ESPP) was carried out as part of the course "Teaching with Technology" offered by the Delta program at University of Wisconsin – Madison. The project was implemented in a college 100-level introductory Astronomy course (Astronomy 104, "Exploration of the Solar System", at the University of Wisconsin – Madison) with the participation of approximately 120 students, the lecturing professor, the course's teaching assistant, and the first author.

Project Learning Goal and Objectives

The learning goal for the project was to make the students understand on of the ways astronomers are able to detect planets around stars other than our Sun and derive properties of such planets via the Doppler detection method. The specific learning objectives were that the students be able to: **1)** understand and use the concept of center of mass, **2)** understand and explain the fundamental principles of the Doppler detection method, and **3)** compute the mass and orbital semi-major axis for a planet given the necessary observational data. *None of the learning objectives had been covered in other parts of the Astronomy 104 course, nor were they part of the syllabus.*

Project Technology - The eTEACH Authoring Tool

The technology chosen for the ESPP was the eTEACH[3] authoring tool developed by Professor Gregory Moses and Dr. Michael Litzkow at the University of Wisconsin – Madison School of Engineering. eTEACH is an innovative multi-media software application that facilitates the creation of an interactive lecture via the World Wide Web (www). The eTEACH software synchronizes streaming video and audio with a slideshow of notes, figures, or animations. The viewer has full control over the lecture via a panel of control buttons and an interactive table of contents allowing easy and fast access to any part of the lecture. Self-assessment quizzes and links to relevant websites can be integrated into an eTEACH lecture to help students probe their learning and allow them to explore further certain topics and concepts. From a given self-assessment quiz, links to the relevant parts of the lecture can be established to encourage the student to go back and review material not fully understood. All contents presented with eTEACH are accessible to screen-reader users (seeing impaired students) and eTEACH makes closed captioning possible to the benefit of hearing impaired students. The eTEACH user interface consists of a video frame, a control panel, a slides frame, a table of content frame, and a web links frame (see Figure 1). The purpose of each of these frames is evident from their respective names, but video and computer animations can be displayed in both the video frame and the slides frame via the capabilities of the lecture tool used (currently limited to Microsoft PowerPoint). The video frame can be expanded to about twice the size when animations are shown.

For the professor, the primary investment of time and energy goes into producing the video, slides, animations, and quizzes to be imported into the eTEACH authoring tool. Segments of video and/or animations need to be paired with slides of notes and/or diagrams. For the ESPP we used ordinary household video cameras, but did have access to equipment such as external microphones, light-reflective screens, and high-end video editing software. (We note that video editing software of sufficient sophistication is often available on personal computers, can be acquired for a modest price, or can be downloaded for free from the www.)

With edited video segments and complementary slides and animations in hand, the process of authoring the eTEACH lecture starts. The eTEACH authoring tool functions around a timeline that allows synchronization between the video, text/notes, and diagrams (to the level of specific animated items in the PowerPoint presentation). Markers on this timeline can be set and labeled with titles that will correspond to entries in the interactive table of contents. Selecting an entry in the table of contents will take you to the marked part of the lecture. When finalized, the eTEACH lecture can be made available on the www from a server at different bit-rates to accommodate students with both high and low Internet connection speeds.

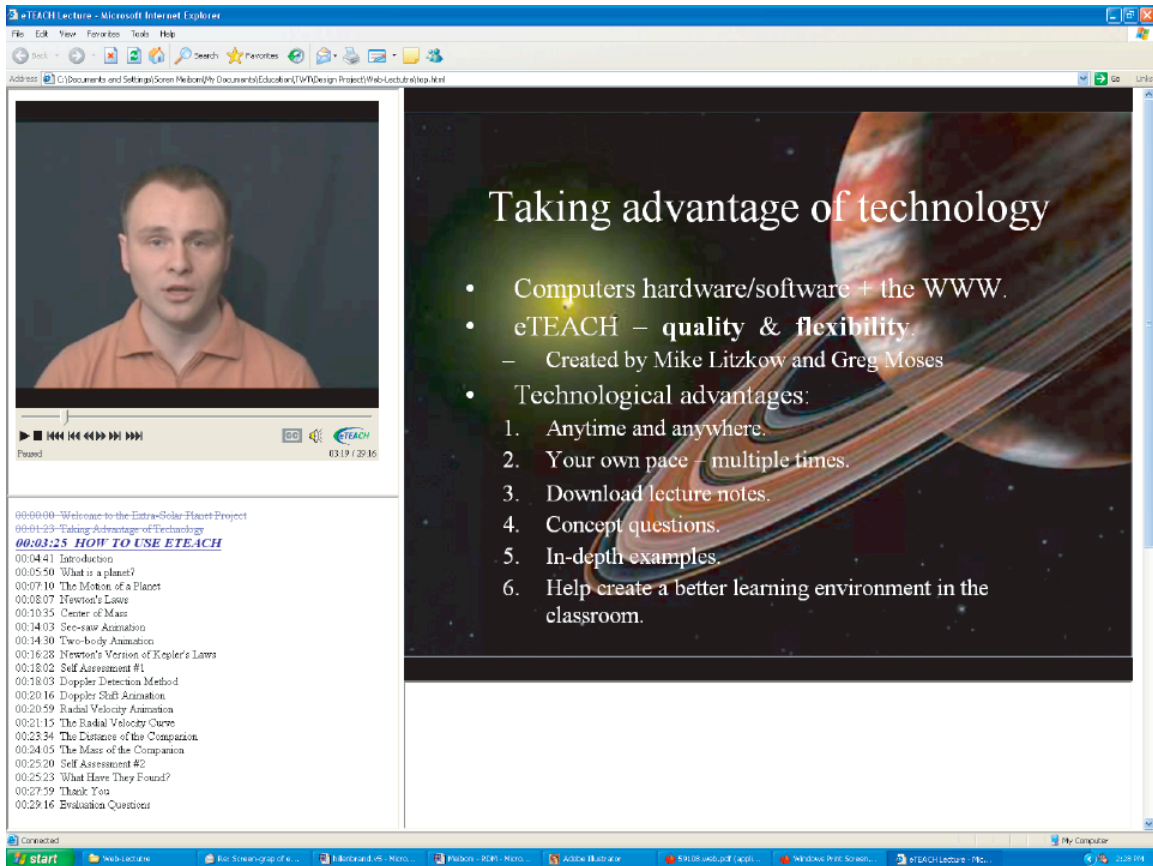[3] http://eteach.engr.wisc.edu/newEteach/home.html

Figure 2. A screenshot from the web-lecture of the Extra Solar Planet Project's web learning-module. The screenshot shows the different frames of the eTEACH user interface. The video frame is located in the upper left corner of the browser window. Below the video frame is the control panel and the interactive table of contents. The slides frame is located in the upper right corner above the (empty) frame for relevant web-links.

Taking Advantage of Technology

The eTEACH web-lecture is the central component of what we here refer to as a web learning-module. The web-lecture was designed to provide the students with the knowledge and tools they needed to reach the specified learning goals and objectives. By fulfilling that, the primary goal of freeing up the scheduled class time to be spent better or differently, is already reached. Importantly, the web-lecture offers a series of additional technological advantages to both the teacher and the students:

1. **Flexibility**. Most obviously, the web-lecture offers flexibility in the sense that the student can choose when, where, and how he/she wants to view it. The lecture will be accessible 24 hours a day and 7 days a week, only limited by the student's access to the Internet via a home or campus computer. This quality, unlike the traditionally scheduled lecture, accommodates differences amongst students in when and where they are ready to listen and learn. For many students this time is not late in the afternoon or early in the morning, and not necessarily the same time every day of the week for every week of the semester. Amongst the students participating in the ESPP the time and place of choice was often the same as where and when they preferred to do other homework.

2. **Accommodating diverse learning styles**. Equally important is the flexibility offered by the eTEACH technology of how frequently and at what pace the web-lecture is viewed. The scheduled college lecture is offered only once and the pace at which information is delivered is most often set by factors other than the average students ability to follow, think, and learn. The unlimited access to the web-lecture, and the control panel and interactive table of content in eTEACH, makes it possible to not only see the entire lecture multiple times, but also to maneuver within the lecture to review more difficult and interesting parts, helpful animations, figures, etc. - and pause for a break when needed. The web-lecture thus accommodates all students, regardless of the speed at which they are capable of learning.

3. **Takes away the distraction of note taking.** The eTEACH web-lecture embraces the frequent complaint from students regarding the dilemma between taking notes and listening to the teacher/professor. Many students find it difficult or impossible to do both without compromising either. Notes, figures, and diagrams from an eTEACH lecture can be made easily available for download by the students before the lecture is viewed. The students can then choose to just listen with notes already in hand or listen and add additional notes when necessary.

4. **Self-assessment with instant feedback and review.** To help the students measure their understanding of the concepts presented to them, eTEACH enable self-assessment quizzes throughout the web-lecture. Such quizzes can present questions simply guiding the student's thinking or multiple choice questions measuring understanding and giving instant feedback as to whether the answer was correct or not. Importantly, for each question asked, the self-assessment quizzes can be made to offer hyperlinks that will take the student back into the lecture where the information relevant to the specific question was provided. This feature provides an easy and efficient way for the student to optimize learning during the lecture, and should be compared to the experience of the traditional lecture of raising a hand to ask a question and perhaps/perhaps not get a satisfactory answer.

5. **Easy access to additional information and in-depth examples.** Finally, when beneficial the web links frame in eTEACH can offer links to in-depth examples for topics and concepts that are particularly difficult to explain in the limited time available during the main lecture, or to web sites on the Internet providing more information.

Project Structure

The implementation of the ESPP in the introductory astronomy course involved 3 distinct phases designed to accomplish the goals and objectives of the project. The 3 phases together constitute the web learning-module. While the web-lecture is central to the web learning-module and carries all the technological advantages listed above, it is primarily a tool to obtain the overall goal of the ESPP – to free up the scheduled time with the students to create a better and more efficient learning environment. The two phases of the web learning-module preceding and following the web-lecture are thus critical to fulfill the purpose of the ESPP and to measure the level of success.

Phase I

The primary goal of the first phase was to measure the student's prior knowledge of the key concepts to be taught in the web-lecture (phase II). A pre-test with 3 questions was designed to measure knowledge about the concept of center of mass, about measurements of the Doppler shift of light, and

about the radial velocity of a star. The students were given ample time (30 minutes) to answer the 3 questions in writing. The 3 questions from the pre-test are shown in Appendix A.

Phase II

In the second phase the students were instructed to view the web-lecture sometime during the week following the pre-test. They were encouraged to make use of the full range of technological advantages provided by the eTEACH software, like being able to access the lecture at their convenience, see the entire lecture or parts of it multiple times, download the notes and figures/diagrams ahead of time, and take the self assessment quizzes and use their instant feedback and easy access to review. As part of the web-lecture – at the end - the students were asked to evaluate the lecture, the format, and the technology by answering 14 questions and send the 14 answers plus free-format feedback to the author. The mean score for each of the 14 questions and the examples of free-format feedback is shown in Appendix B, and discussed below.

Phase III

During the week following the web-lecture the presented topics and concepts were reviewed during the scheduled discussion sections. The review was centered on a realistic example of how astronomers use the Doppler Detection Method to derive basic properties of extra-solar planets and their orbits. A key purpose of this phase of the ESPP was to create two different learning environments for the review. One in which the course's professor or teaching assistant described and solved the example problem on the blackboard, allowing the students to ask questions. This was close to the typical procedure for the course. For the purpose of easy distinction between the two different learning environments, we refer to this environment as "passive". In the other half of the discussion sections we divided the students into groups of 3-4 persons. Two teachers (the course's professor or teaching assistant and the author) were present and available to guide the students as they worked on solving the same example problem with each other's help. We refer to this learning environment as "active".

At the end of all discussion sections the students were given a post-test. Three out of four of the questions on the post-test were the same exact questions as on the pre-test. The post-test was designed to serve two main purposes: 1) Compare the pre-test performance to post-test performance for individual students and groups of students and thereby assess the success of the web-lecture to effectively teach the key concepts. 2) Explore and compare differences between pre- and post-test performance for students and groups participating in the two different learning environments during the discussion sections (phase III).

The 4 questions on the post-test are shown in Appendix A, and the example problem (group project) on the Doppler Detection Method is shown in Appendix C.

Student Self-Assessments and Evaluations of the Web-lecture

At the end of the web-lecture the students were asked to answer 14 questions to evaluate their own learning and the web-lecture, its format, and the technology used. The 14 questions and the average score for each are listed in Appendix B. A total of 93 students answered the questions. For each question the students were asked to answer with a number between 1 and 5 according to the following key: 1=poor, 2=inadequate, 3=adequate, 4=good, 5=excellent.

Student Self-Assessments

The purpose of the first 6 questions was to have the students give an assessment of their own net learning. The questions asked for an assessment of their understanding *before* and *after* the web-lecture of the key concepts of center of mass (Q1,2), the Doppler detection method (Q3,4), and of how astronomers detect extra-solar planets (Q5,6). Figure 3 shows the mean of 93 before and after scores. In all three areas probed, on average, the students find that their understanding has improved from inadequate/adequate to good as a result of viewing the web-lecture.
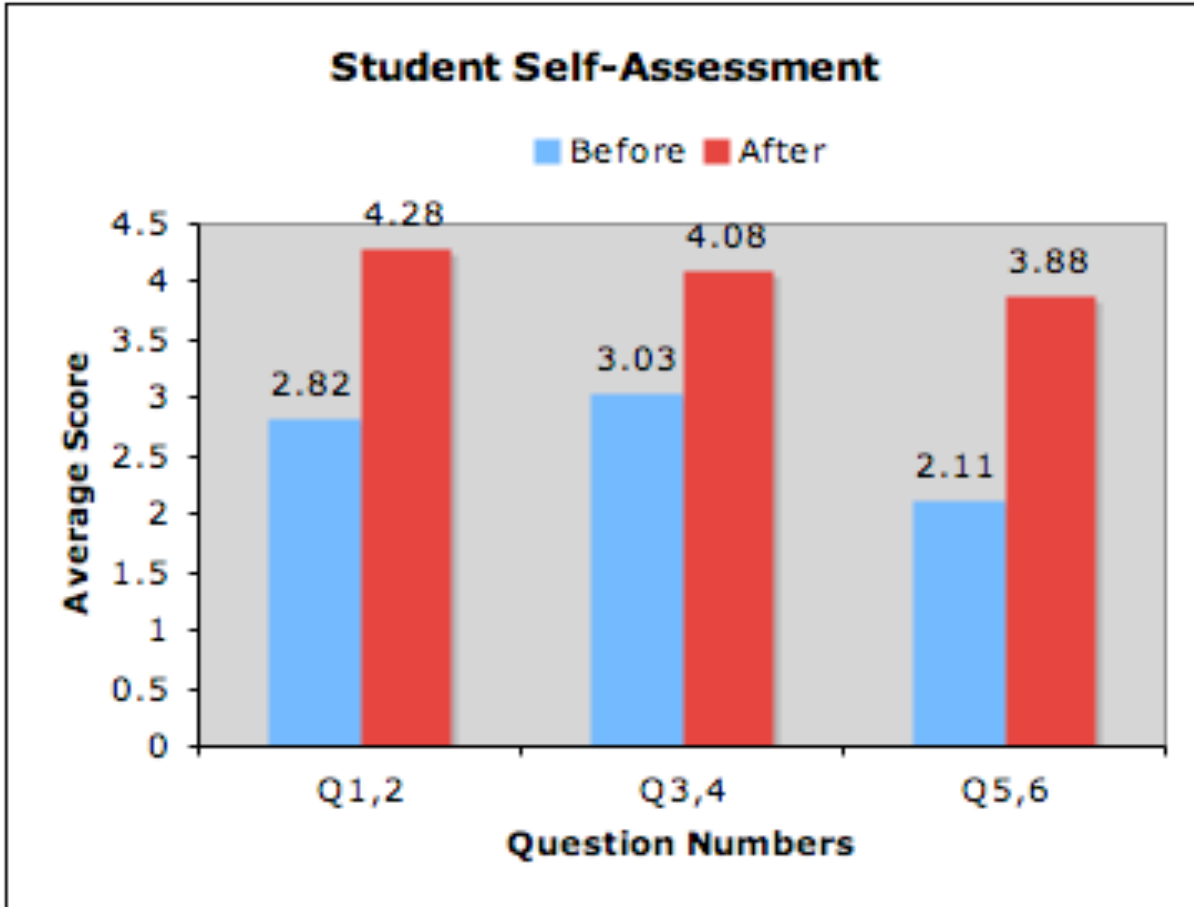

Figure 3. The average before and after scores from the students answers to the self-assessment questions at the end of the web-lecture. The students were asked to evaluate their own understanding before and after the web-lecture of the concepts of center of mass (Q1,2), the Doppler detection method (Q3,4), and of how astronomers detect extra-solar planets (Q5,6). A total of 93 students answered the 6 questions (see Appendix B).

Evaluation of the Web-lecture and eTEACH

The goal of the remaining 8 of the 14 questions was to get the students evaluation of the web-lecture itself, of the web-lecture as an alternative to the traditional classroom lecture, and of the usefulness of some of the technological advantages offered by eTEACH and of the ease of use of the software. Specifically, questions 7 and 8 ask for an evaluation of the effectiveness of the animations and PowerPoint slides, respectively, in helping the students understand the material. The average student scores for these questions were 4.11 and 4.13, indicating that, on average, the students found the

animation and slides to be a "good" help. Questions 9 and 10 address the web-lecture's ability to make the material interesting and to capture and maintain the student's focus. The average scores of 3.63 and 3.37 tells us that students found that the web-lecture was "adequate" to "good" in terms of presenting the material in an interesting way and keeping their attention throughout.

Questions 11 and 12 ask the students to compare the web-lecture to the traditional lecture in terms of the effectiveness in communicating the material and in terms of the quality of the lecture. Question 13 asks directly for a rating of the web-lecture as an alternative to the traditional lecture. The average scores for the last three questions are 3.87, 3.70, and 3.63, respectively, suggesting that students in general found the web-lecture to be "adequate" to "good" in quality and in communicating the material, and that the web-lecture is an "adequate" to "good" alternative to the traditional lecture. Finally, question 14 asks the students to rate the eTEACH software in term of its ease of use. The average score of 4.25 translate into "good" to "excellent".

Free-Format Feedback

In addition to the 14 questions we also asked the students to give us "free-format" feedback via email. While encouraging a free format, we asked them to at least consider these 3 questions:

1. What did you like and did not like about the web-lecture?
2. What worked well and didn't?
3. Could you imagine watching lectures in this format and then spend the class-time discussing the material and work on related problems?

Forty-five students included free-format feedback in their email responses, all of which can be found in Appendix D. This type of feedback proved particularly valuable as it reveals strengths and weaknesses of the web-lecture itself, and shows some shortcomings on our part in communicating to the students the role of the web-lecture as only one part of an entire learning-module. Importantly, the free-format feedback provides us with a list of comments and criticisms that will help us to improve all 3 phases of the ESPP and similar future web learning-modules.

The students expressed a number of concerns and positive/negative comments repeatedly. We will make general formulations of those here, as they will be the foundation for the "Lessons Learned" Section below. The most frequent positive feedback was related to the flexibility offered by the web-lecture. Specifically being able to go back and watch parts of the lecture multiple times received warm reviews. To be able to watch the lecture at a time most convenient and to download and print the Power Point slides, and thus not having to take notes, were also expressed as definite advantages of the web-lecture. Many students expressed an ease of use of the technologies (eTEACH + Internet) with relatively few students having experienced difficulties with software and/or hardware. This latter trend lines up with the high average score in response to question 14 in the questionnaire at the end of the lecture (Appendix B).

The most frequent negative feedback was expressing difficulty focusing or staying focused on the lecture, and an experience of the lecture being monotonous and lacking stimulation in comparison to the traditional "live" lecture. Several students expressed that lack of participation (like asking questions) made it easier to get distracted. One recurring negative feedback was related to the misunderstanding that the web-lecture would replace the scheduled time with a professor and thus take away their ability to ask questions and provoke discussion about difficult topics (the exact is the main motivation for the ESPP).

An important outcome of the free-format feedback was numerous good suggestions for improvements and changes to the lecture. Logically, they are mostly suggestions on how to solve the problems and address the concerns expressed. The suggestions include changes to the video component of the lecture to make it less monotonous with more frequent variations in the filming

location/background, inclusion of more animations and pictures, availability of notes in formats different than Power Point, and ways in which to counter the inability to ask questions during the lecture. Some of the suggestions were originally considered in the planning phase of the ESPP, but were cut later due to constraints on time or technical capabilities. However, many were new ideas, and all of them will be given serious consideration in planning and design of future web learning-modules.

Assessment of Student Learning

Here we ask the questions: 1) Did the students gain understanding of the key concepts taught in the web-lecture? 2) How did the learning environment following the lecture affect their learning?

We attempt to answer these two questions based on the students performance in the pre- and post-test and based on their participation in the "active" or "passive" learning environment during phase III of the ESPP. To assure a fair and unbiased grading of the pre- and post-tests from all 6 discussion sections, we constructed a rubric for each of the test-questions. Each rubric was designed to probe the students' knowledge of the learning objectives. The same rubrics were used to grade the pre- and post-tests. The tests were graded without knowledge of the learning environment.

We display in Figure 4 the difference in the mean pre- and post-test scores normalized to the standard deviation in the pre-test score (the effect size) for each of the 3 questions in common between the two tests (Q1,2,3), and for the total score. The 1-sigma error bars on the effect sizes are calculated as the square root of the sum of the squares of the standard errors on the mean pre- and post-test scores normalized to the standard deviation in the pre-test score. Blue and pink symbols, respectively, are used to show the effect sizes for students that participated in the active and passive learning environments.

The effect sizes for all 3 questions, and for the totals, are all significantly higher than zero. This result tells us that all students, independent of the learning environment, gained understanding of the key concepts from the web-lecture and the following discussion section. The smallest combined (active and passive) gains were for question Q2 in which the students were asked to move the seesaw's fulcrum to balance the father and son. While the concept of center of mass was discussed in proportion (nearly 5 minutes) in the web-lecture, it is possible that the lower effect size for question Q2 reflect less emphasis on this concept in the group problem solved in the discussion section prior to the post-test.

We find the answer to our second question about the effect of the learning environment, in the difference in effect size between the students participating in the active and passive learning environment. For both questions Q1 and Q3, and for the total scores, the effect size for students participating in the active learning environment is significantly higher than for students participating in the passive learning environment. For question Q2, the difference, although slightly in favor of the active learning environment, is very small and insignificant. This result suggest that students participating in the active learning environment experienced a significantly larger gain in their understanding of the key concepts than students participating in the passive environment.
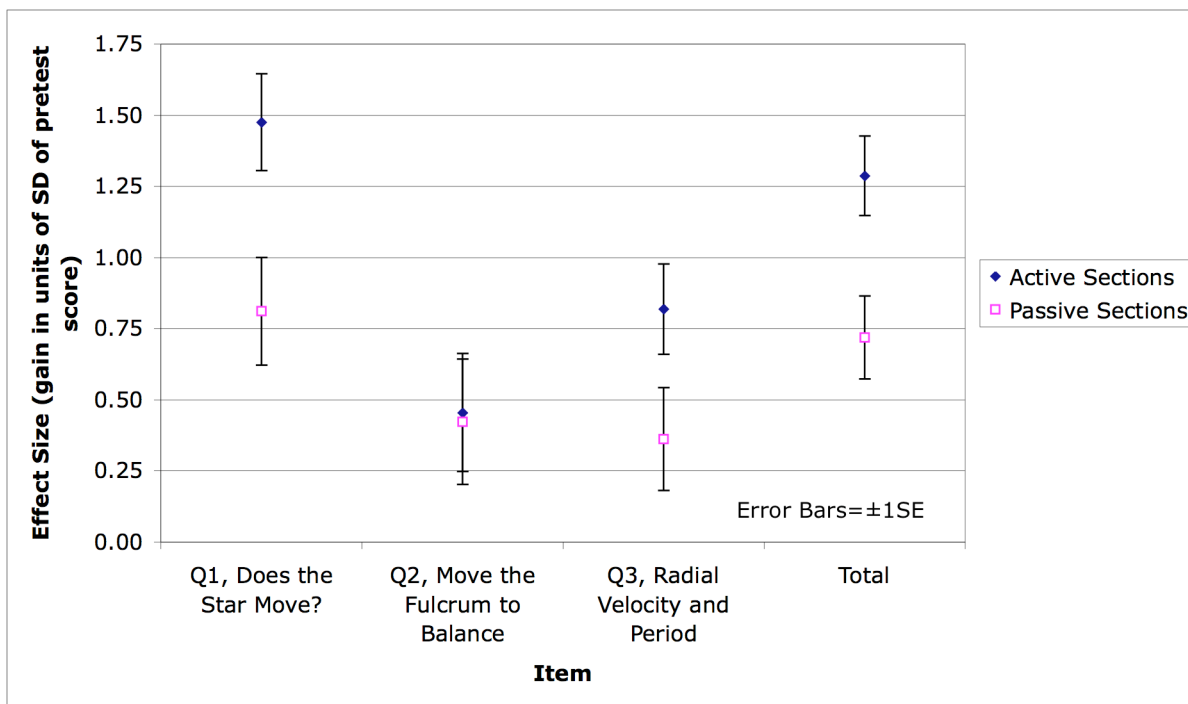
Figure 4. The effect size with 1-sigma error bars for the 3 questions (items; Q1,2,3) in common between the pre- and post-tests, and for the total score. Blue and pink symbols, respectively, are used for students that participated in the active and passive learning environments.

Lessons Learned

We focus here on the most frequent criticisms and suggestions for improvements from the free-format feedback, as they will be central to future implementations. A recurring criticism was that the close-up "talking head" in the video frame was too much of the same. This criticism was often followed by suggestions of how to improve this by changing the scenery/background when producing the video. Making use of several different indoor and outdoor filming locations was part of the original plan for the web-lecture, and will be done for the future. The change in scenery should make watching the lecture more enjoyable and thus make it easier for the students to stay focused.

Some students expressed that there was too little interaction between them and the web-lecture. They missed being able to ask questions and/or briefly discuss with fellow students. While there will be plenty of time for discussion with fellow students in the active learning environment planned to follow the web-lecture, we recognize the need of the student to be able to ask a question as it forms in their mind – and not a week later. Our original plan to accommodate such typical in-lecture questions was to set up a combination of a chat-room for students to ask each other questions, and an email address to which questions could be submitted to the teacher. Questions submitted to the teacher could be answered by email directly as soon as possible, or be discussed in class at the scheduled classroom time. Ideally, both the chat-room and the email features would be incorporated into the eTEACH software. This is not currently possible.

Many students liked the self-assessment quizzes and would like a higher frequency of such mandatory and/or voluntary self-assessments or similar constructive breaks in the web-lecture. We think it is a good idea to increase the number and decrease the size of self-assessment quizzes. The multiple-choice format is desirable because it enables immediate feedback. To collect the data from the self-assessment quizzes was also an initial idea, as it would give us the opportunity for tracking

student learning throughout the lecture. Again, this would require modifications to the eTEACH software.

Some students expressed concerns that web-lectures would take away their classroom-time with the professor. The exact opposite was of course the goal of the ESPP. We must do a better job of communicating to all students the main motivation for the web-lecture – to make better use of the classroom-time with the teacher.

In future implementations we wish to also ask on the post-test whether the student watched the web-lecture or not. For the ESPP we asked the students (orally) during the discussion section if they watched the lecture. This informal survey suggested that the vast majority of students had watched all or part of the web-lecture.

Conclusions and next steps

From the student self-assessments and from our own assessment of student learning, we conclude that the web-lecture was capable of effectively introducing the students to key concepts they had not been taught earlier in the course. From our analysis of the pre- and post-test data, we conclude that the students, independent of the learning environment, made significant gains in their understanding of those key concepts from the web-lecture and the following discussion section. These are important results because they suggest that the tested web-lecture was a viable alternative to a traditional lecture, independent of the subsequent learning environment. From our analysis of the pre- and post-test data and with a focus on an effect of the learning environment in the review section, we conclude that overall, and specifically for 2 of the 3 key concepts, students participating in the active learning environment made significantly higher gains in their understanding of key concepts than students participating in the passive learning environment.

We are encouraged by these results, and by the general willingness and enthusiastic participation of the students. Due primarily to their feedback, we have a list of well-defined tasks that can be carried out to improve the format and content of the web-lecture. Importantly, the student's evaluation of the eTEACH software was very positive, as was our own experience working with eTEACH.

The web-lecture created with eTEACH is an exciting new tool to help professors meet the need for an active, flexible, and discovery-based learning environment by freeing up the scheduled classroom-time for learning rather than instruction. The web-lecture offers freedom and flexibility for both the students and the professor in ways that can help accommodate diversity in the student body, such as differences in learning style and speed, and in academic and cultural backgrounds. Importantly, the eTEACH software also accommodates students with special needs.

It is our ambition to build upon this positive experience, and to create more and better web learning-modules to be implemented into college-level astronomy courses. To produce the web learning-module, assess student learning and feedback, and make changes to optimize student learning, is a dynamic and ongoing process – just like research. We recognize that to include graduate students and senior undergraduate students in this process will be a great way to prepare and motivate them for their future careers as teachers, and to show them that their skills as researchers can be also be applied to improve their performance as educators.

Acknowledgements

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Appendix A

In this appendix we present the questions asked of the students in the pre-test (ESPP phase I) and post-tests (ESPP phase III). Question 4 was added to the post-test and was not used in the assessment of the net student learning.

<u>Pre-/Post- Lecture Quiz (Extra-Solar Planet Project, Phases I and III)</u>

Student Name (please PRINT): _____

Discussion section (day, time): _____

1. Imagine a solar system where Jupiter is the only planet orbiting the sun. As Jupiter revolves around the sun, does the sun move? Argue *why* or *why not*. (Ignore the sun's motion in the Milky Way.)
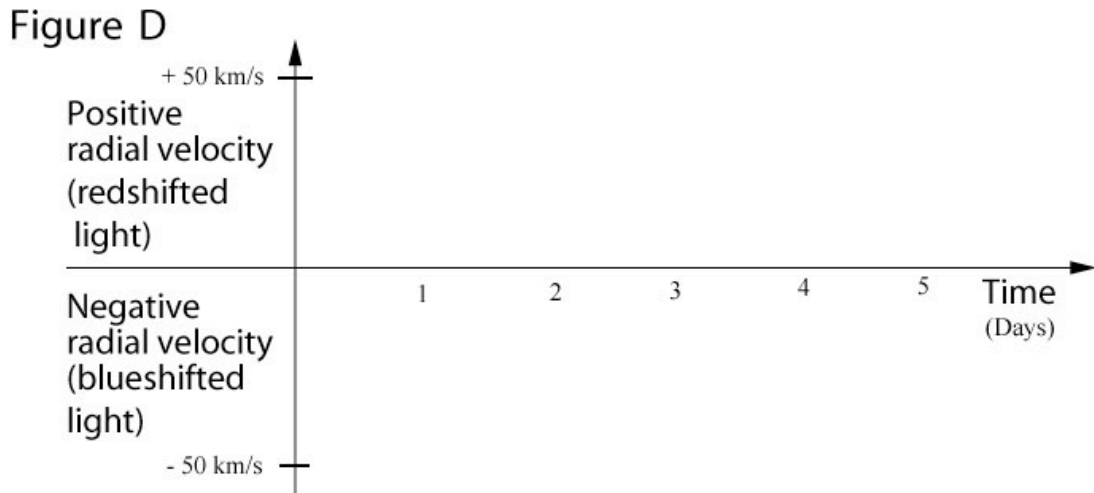
<u>Answer:</u>_____

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2. Consider a father and his son sitting on each end of a seesaw. The father weighs 200 pounds and his son weighs 100 pounds. The seesaw consists of a 10-yard long board and a fulcrum, which is located between father and child (see Figure A below). How would you move the fulcrum so that the seesaw would balance father and child horizontally? Mark the new location of the fulcrum on Figure B and give the distance (in yards) from the fulcrum to father and son, respectively.

<u>Answer:</u>_____

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_____
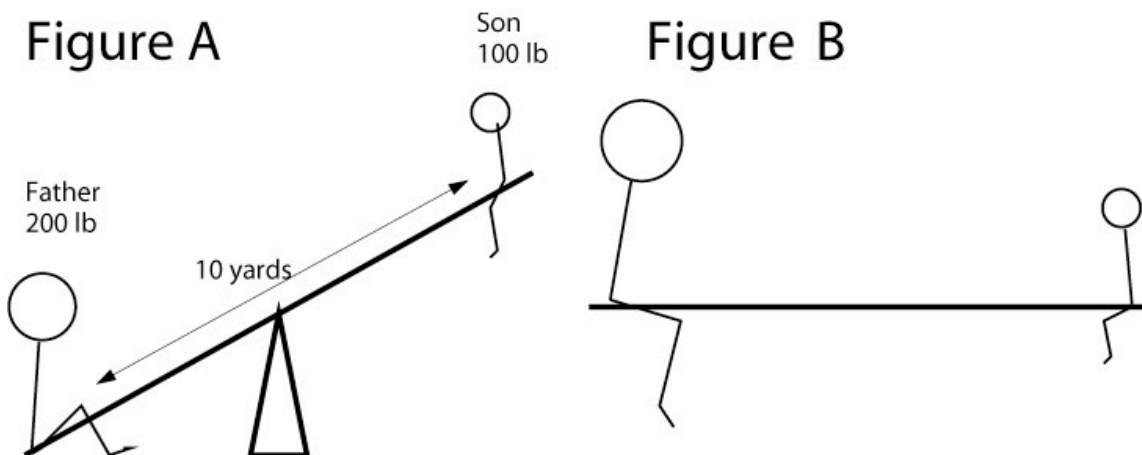
3. A star like the sun is moving in a circular orbit with an orbital velocity of 50 km/s. You as an observer are looking at the orbit edge-on (see Figure C below). By measuring the star's Doppler shift you calculate its radial velocity at every point in its orbit. In Figure D sketch how the stars radial velocity will change over time.

Figure C   Time = 0   Observer

Time = 1 day

Time = 3 days

Time = 2 days

Star in circular orbit

Figure D

+ 50 km/s

Positive
radial velocity
(redshifted
light)

             1   2   3   4   5   Time

Negative
radial velocity
(blueshifted
light)

                                                        (Days)

- 50 km/s
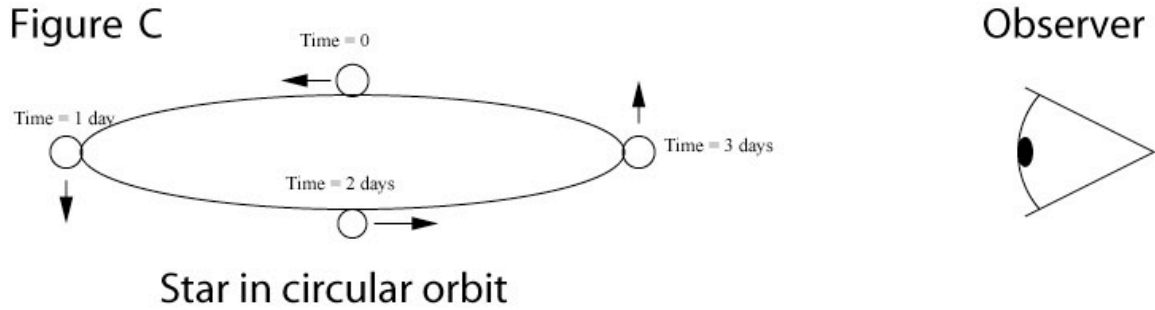
You have created a "radial velocity curve". Show in Figure D how can you find a star's orbital period from a radial velocity curve.

4. Consider a star like the sun (Mass = 1 M_{sun}) with one planet like Jupiter (Mass = 1/1000 M_{sun}) orbiting in a circular orbit with a radius of 1 AU. Make a sketch below of the star-planet system as seen "face-on" ("from above" or at a 90^0 angle between orbital plane and line of sight). Mark the center of mass on your sketch and draw the orbits of the star and the planet. Specify the distance from the star to the center of mass and from the planet to the center of mass.

Appendix B

For the purpose of student self-assessment and to get a student evaluation of the web-lecture, we asked the students to answer 14 questions at the end of the web-lecture. The questions and the average scores from 93 in parentheses are listed below.

Student self-assessments and evaluation of the web-lecture:

Please rate the web-lecture format by answering each of the following questions using this scale:

(1=poor; 2=inadequate; 3=adequate; 4=good; 5=excellent)

1. How was your understanding *before* this web-lecture of the concept of center of mass? (2.82)
2. How is your understanding *after* this web-lecture of the concept of center of mass? (4.28)
3. How was your understanding *before* this web-lecture of the Doppler Detection Method? (3.03)
4. How is your understanding *after* this web-lecture of the Doppler Detection Method? (4.08)
5. How was your understanding *before* this web-lecture of how astronomers detect extra-solar planets? (2.11)
6. How is your understanding *after* this web-lecture of how astronomers detect extra-solar planets? (3.88)
7. How effective were the animations in helping you understand the material? (4.11)
8. How effective were the Power Point slides in helping you understand the material? (4.13)
9. How do you rate the web-lecture's ability to make the material interesting? (3.63)
10. Compared to the traditional "live" lecture, how do you rate your ability to stay focused during the lecture? (3.37)
11. Compared to the traditional "live" lecture, how do you rate the ability of the web-lecture format to communicate the material? (3.87)
12. Compared to the traditional "live" lecture, how do you rate the overall quality of the web-lecture? (3.70)
13. How do you rate the web-lecture's potential as an alternative to the traditional "live" lecture? (3.63)
14. How do you rate the ease of use of the eTEACH software? (4.25)

Appendix C

<u>The Doppler Detection Method (ESPP Phase III)</u>

You and your team are searching for planets around nearby solar-type stars. You have observed star X (a G2 star like the sun) for 15 nights with a frequency of once per night. Using a telescope equipped with a spectrograph you have measured the Doppler-shift of the Calcium K absorption line in the stars spectrum. You have recorded the *time* of your observations (in days) and the *Doppler-shift* (in nm, 1 nm = 10^{-9} m) of the Ca K line relative to its rest wavelength (393.3680 nm). Your observational data are listed in the table below.

Time (days)	Doppler-shift (nm)	Radial Velocity (m/s)
0.0	0.0001104	
1.0	0.0001198	
3.0	0.0000225	
4.0	-0.0000993	
5.0	-0.0001389	
6.0	-0.0000209	
7.0	0.0000885	
8.0	0.0001276	
9.0	0.0000594	
10.0	-0.0000641	
11.0	-0.0001340	
12.0	-0.0000757	
13.0	0.0000130	
14.0	0.0001339	
15.0	0.0000876	

1. Calculate the star's radial velocities corresponding to the observed Doppler-shifts and plot your results in the diagram below.
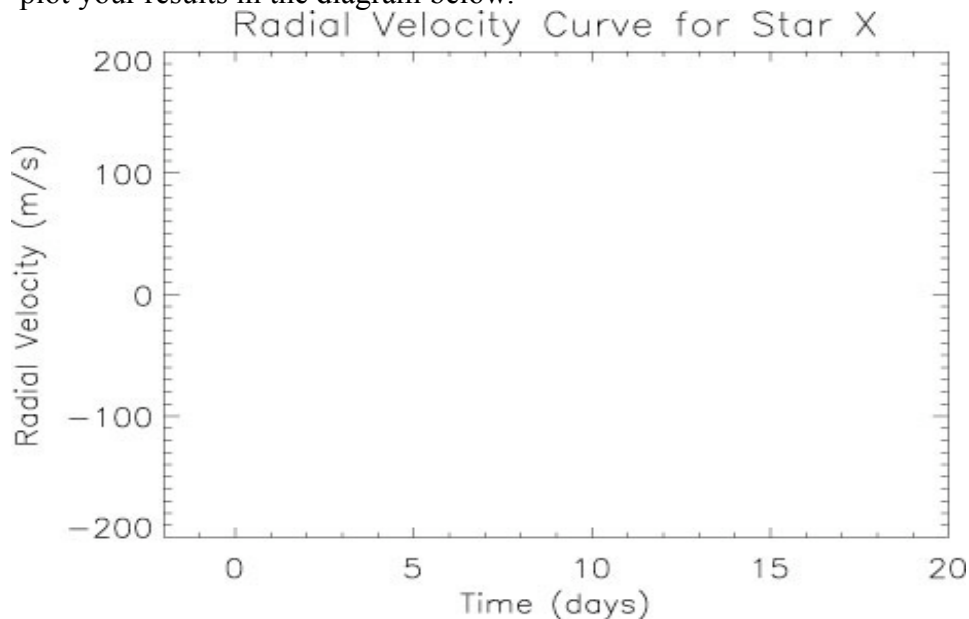
You have created the radial velocity curve for star X.

2. In the blank space below make a sketch of what you know about star X based on the observed radial velocity curve.

Sketch:

From the Web-Lecture you are familiar with Newton's version of Kepler's III law, the law of conservation of momentum, and the relation between period and orbital velocity in a circular orbit:

$$P^2 = 4\pi^2 a^3/G(M_{star} + M_{planet}) \cong 4\pi^2 a^3/GM_{star}$$

$$M_{star} \times V_{star} = M_{planet} \times V_{planet}$$

$$P = 2\pi a/V$$

Mass of a G2 star $= 2\times10^{33}$ g; $G = 6.67\times10^{-14}$ g^{-1} m^3 s^{-2}; 1 AU $= 1.5\times10^{11}$ m

3. How will you use this knowledge to conclude your study of star X?

Appendix D

Free Format Feedback from students that watched the web-lecture
(The comments have not been edited and are listed in the order received via email):

1. I really liked how you could stop and rewind if you didn't get it the first time. it's also very nice to have power point in synch with the lecture as well to always get a visual effect. I could imagine watching lectures that way, it would be different at first but I think it would be great to take advantage of this technology. Thanks

2. The web lecture was pretty easy to use and I enjoyed it but it was not much easier to pay attention here than in class. I like the idea of being able to watch it again in case I didn't understand something the first time. I would still want to have some in class time to ask questions and discuss though.

3. It was difficult to advance the powerpoint slides in a certain chapter of the powerpoint it seemed to want to jump ahead when you pressed next. I was very impressed though with the quality of the video and the synchronization of the powerpoint. Very good lecture.

4. It was interesting watching a lecture on the Internet. I can see this being a beneficial and useful technique in the future. It was nice being able to stop the lecture and listen to a segment again. One thing that is a concern is when students have questions. You cannot ask the computer a question. Even though you can stop the lecture and go back, something still might not be clear to the student and since they do not have the option of raising their hand to ask the professor and get it cleared up at that moment they might listen to the entire rest of the lecture not understanding what is going on because they were not able to clear up a single point at some time during the lecture. This is the only negative aspect I can find in the whole process. Otherwise, I think this is a great tool and I will be looking for this technique to be used in some of my classes in the future.

5. I wasn't particularly fond of the format of the lecture. Even though i had all of the software, and hardware for that matter, I was't able to view the slides and the lecture at the same time. I had to go into the power point program to see them both at the same time. As far as staying focused, I had a hard time doing so since my computer was acting up. I think if this is done in the future, a TV format may be appropriate. Where, you do the same thing you did, but have it on a specific channel running smoothly without all the personal computer glitches. Otherwise, it was very interesting, and I felt i was able to learn a lot.

6. I feel that online lectures are an excellent tool for learning, and a good supplement to course work. I don't really think it's possible to replace an actual person, but I do see the advantages to this system. I like the fact it is possible to watch the lectures multiple times. I only have one suggestion; I think there should be an option to print out the notes in an outline form, as opposed to just the powerpoint slides.

7. Wow! That was an awesome lecture format! I have to be honest, I thought this was going to suck, but it was great! I really like that you can go back and revisit a concept that you may not have gotten the first time around. (I don't know how many times I have wished I could do this with a live professor). I think this would really free up time for more in depth study of subjects. If a person can get the knowledge base they need before they come to class, then they can really explore what that concept means not only for them but for the world at large. Great job guys!!!

8. The lecture was very interesting, very easy to use.

9. I thought that the web lecture was put together very well, but I found it a little hard to follow at times. I think it would definitely take more self-motivation on the part of the student to sit down and watch these lectures as an alternative to going to a class. I think this could be particularly difficult if people do not have a quiet place to sit down and focus on the material being given to them. I did like that you could go back and click on previous slides...that was helpful for taking notes. The only disadvantage I would see to this is not being able to ask questions at the time that you have them.

10. I thought it was helpful to be able to hear about what you are seeing on the slides while viewing them. Also being able to go forward and back to go over things at your speed worked well.

11. I thought the lecture went really well. One thing that could have had a little more explanation was the self assesment part. It went by so quickly that it took me a little while to realize what it was.

12. I think that the idea of having lectures on the web as an alternative or an extra to lectures in class is a good idea. It may work well, in some cases better, for some students. I did not find the lecture to be as simulating as normal classroom lectures. I think that it lacks an element of reality since it is recorded and not taking place live in front of you. I can tell that A LOT of time and effort has been put into this lecture, but it's just not interesting enough (for me) to look at and to make me excited about the material. I do not find that the lecture is able to spark enough interest for effective, active learning. Eteach may be a nice second option, but if the classroom is to be replaced one day by the internet, i can only see that resulting in a negative effect for education. I would rather learn on my own experiences without a degree than paying to "go" to school for on-line lectures.

13. The animations accompanied witht the lesture were very helpful. I also liked the fact that I could stop the lecture at any point or go back and review an animation if I didn't understand the first time.

14. I really like web lectures because I can pause to catch up on note-taking and go back and review. I also like this particular software because it gives options for hook-up(campus, dial-up). This was an interesting lecture.

15. Comments: I like the fact that the web lecture is conveinent, however, I don't feel that I web lectures are a good alternative to "live" lectures. I'm not a big computer fan, so I would rather attend classes and be able to participate, ask questions, and focus on certain topics while I'm learning the material. This was helpful, but also impersonal and couldn't go as in depth as I feel lectures allow. Classroom energy and presentation is an important way to focus, and there are just too many distractions while sitting on my computer. However it was easy to use (which was great!) and would be great as an introduction to class topics, but definitely not a substitution to the traditional lecture. Good job! :o)

16. I really liked the eTEACH lecture. It was informative and interesting, and it was nice to be able to be in my room eating lunch and learning at the same time. I also appreciated being able to 'rewind' the lecture when I did not understand something. The only faults I observed in the eTEACH lecture were within the technical parts of the program. Sometimes when I would rewind the program I would have to shut down and restart it because I lost the power point slides. Other than that, I found the experience to be a positive one.

17. I really didn't like the web lecture, maybe I'm just spoiled with Prof Mathieu's interseting lectures, but I found it hard to stay focused and understand the concepts. Moving back in the lecture was annoying because it took awhile for it to play (after buffering, etc), and in the little self-tests the "Review" buttons were all tagged to the same page so that wasn't much help. I love going to live lectures and being able to have the Prof right there in front of me to respond to feedback from us, to clarify things then and there while it is still fresh in our minds. And the in-class demonstrations using volunteers from the class is very helpful, as is having classmates all around you to ask questions to also. I hope this university stays with the traditional, live-lecture format.

18. Free Response: First off the lecture was a little hard to watch because all the dialogue was read off of CUE cards! This is hard to watch! This is a great format, but the speaker needs to be lively. This is a good use of time and could be great to address things that you don't get into during class. This lecture was great on background, but did not draw the close connection between astronomers and what tools the use to find extra solar planets. Also, more history and pictures would be great in a section like that.

19. I liked the web-lecture. However, i was finding it difficult to sit at my computer without interacting with it such as typing in answers and such. I thought the slides worked well, but I think there should be some questions or some interaction between the lecture. After such changes I could imagine watching lectures in this format and then spend the class-time discussing the material and work on related problems.

20. I think the web lecture was good, however I think there are still some technical gliches to work out yet. I think having the powerpoint slides on the class website as usual would be really helpful. I think the lecture needed better navigational areas like going from slide to slide and going back to a slide that went too fast. Otherwise I liked the lecture, but still think that having a live professor would be much better.

21. In response to question 13, I rated the potential of this new style compared to the traditional lecture so low is because in my opinion, if I was going to pay tuition to have all of my classes online, I would not pay it to a university such as the UW, but I do think that this format would be useful for more abstract material that would be covered in discussion sections, like this material.

22. I pretty much enjoyed the lecture of this format. However, I found this lecture to be a little too hard to follow with all the equations.

23. I thought this was a great form of lecture on the topic. I thought the animations helped present the ideas very well. The software was a little dificult to maneuver with the self-assessments, but not too bad.

24. Thanks for all your hard work. I liked that you could go back and review things if you didn't understand them the first time. It was hard for me to stay focused. Since I didn't have to watch all of it at the same time, I didn't take it as seriously as I would a traditional lecture. Also, there's no way of asking questions during the web lecture. I could see using this format. I've had one web-based class and the only problem I had was I kept putting off the lectures. Since I could view them at anytime, it was hard to keep myself motivated. If the course were to move to the web there would have to be some sort of daily quizzes/homework that would keep students on top of the lectures. Otherwise students are just going to put them off till the end, try to ram it all in, and not have enough time to process the information or ask enough questions.

25. I liked being able to stop and repeat sections, and write down things that I missed the first time through. I didn't like the monotony of watching a person in the corner of the screen for half an hour. I think the lecture worked well for what it was, but I don't think it is a good replacement for class lectures. I think it would be very possible to use this format for discussions, or for basic overviews of topics. However, I think seeing someone in person, and being able to hear the thoughts and questions of students hearing the same thing as you are is something that can't happen with the web lecture.I think it would be easier to have miscommunications.

26. I felt the weblecture format was very useful and helpful. The topic was interesting as well. The animations can be integrated well into the lecture which makes the topic more understandable. Overall I feel that the web lecture is at least as effective for conveying material as a standard live lecture.

27. It was a good overall experience. The software could use a little debugging. To increase the interest maybe some more animation could be added to display ideas. Otherwise I think the ability to watch at your own convenience and the ability to watch multiple times is great. Great job to all.

28. I think this was very easy to use and very helpful but i can see how it might be difficult to grasp more difficult subject matter in this format. Overall though i think it was great.

29. I found the lecture to be quite useful in learning the new material. I really liked the slides being next to the professor window, and also the outline was quite nice as well. The only problem I had was writing down the stuff off of the slides, but that can be taken care of by printing the slides of beforehand which is also a very good idea. Too often in lecture I get caught copying something off of the board or screen and miss the comments that the professor makes about it, so that is extremely helpful in taking notes, to have the slides. Overall, I like the format of the weblectures.

30. Overall very good--I think this would make a great format for lecture! I like the powerpoints being combined with the web lecture; I think it helps a lot.

31. I thought the web lecture was interesting, although I think it is a lot easier for me to concentrate and focus in a live lecture--I hate not being able to ask questions. The biggest problem I had with the web lecture is that once we had looked at Kepler/Newton's laws and the Center of Mass equation, the lecture became kind of hard to follow--there were a lot of equations without a lot of explanations for them. Overall, though, I thought it was interesting. Thanks

32. Put some emotion into your talking, it'll make the subject seem more interesting and keep the student's attention, you may be on the computer, but you're still a person with a personality. The lecture was good overall, a little dry, but good. The thing about the Doppler shift was confusing because I was missing the 'edge on view' concept. I understand the Doppler shift, but I don't know what you're trying to say when you explain it in the lecture. If the star is moving away from you, there will be a redshift, and if the star is

moving towards you, there will be a blueshift, right? Maybe I just missed something. Good work.

33. The only criticism I would have is over the long pauses and oddly emphasized sentences in the beginning. I didn't run smoothly together. I talked to you at the observatory once, and you seemed much more charismatic and easy to understand. I think this is something you can correct easily, or maybe you already have because it got much better as the lecture went on. The only suggestion I would have on doing things differently is maybe it shouldn't always be a close up of your face. Just like professors walk around and use body language in class, i think that would be helpful for eteach. A closeup of someone talking for a while just gets hard to keep looking at. At little movement and a background setting (I'd imagine a classroom, or maybe even some cool space picture superimposed behind you) would keep people more interested.

34. Overall I really enjoyed the online lecture. I think it has possibilities, but I'm not sure how well it would do completely replacing a "live" lecture. Thank you.

35. I felt the Lecture was a little slow paced and that some of the stuff taught during it was not very complicated and probably did not need to be covered. I enjoyed looking at the slides and seeing exactly what he was saying on paper, it made it easier for me to learn. I think it would be a great idea to watch lectures on line and then use the lecture time to discuss what we learned and get more in depth asking questions of the professor and allowing us to understand things better.

36. In general, I had a hard time getting to video to run on my computer and therefore had to rely only on the powerpoint slides which made understanding the lecture a lot more difficult. I also like the live lectures better just because we can stop it and raise our hands with questions. There are still a few points regarding this lecture that I am unsure of and if tested on this I doubt that I would do very well, its hard to stay focused.

37. The web-lecture was very easy to use and it made the lecture easy to understand, but the explainations of the caculations relating to the Doppler Shift dection method were a little hard to follow, maybe showing the equations where the terms came from would be helpful.

38. I had a little bit of trouble with the animations. This is most likely because I have a dial up connection and it wasn't very fast. Throughout the lecture it had to stop to "buffer". It took me almost an hour to complete the web lecture with the connection that I had.

39. Overall, it would have been a lot better, but there were a lot of technical difficulties (and maybe a better explaination of how to work the software would have been helpful)

40. I really enjoyed this type of lecture. It allows students to move as quickly as they'd like or to review material. In addition, questions could be addressed at greater length during scheduled lecture. I wish that the class had done more classes like this earlier this year. It would definately make studying for the final easier.

41. I thought this was a great innovation as well as a nice way for a student to understand a lecture on multiple levels of learning by listening and interacting, as well as being able to go through it at their own pace. The only thing I would change is to perhaps add in some way of answering frequently asked questions to ensure all aspects were as clear as can be.

42. I like that I can watch the lecture any time, and be able to pause, rewind and stuff like that. The one downfall is not being able to ask questions right away when they come up during the lecture.

43. I didn't really care for this format of lecure very much. It's hard to watch the computer screen and stay focused for the whole thing. Also, I had problems with the slides coming up. For some reason they wouldn't change when they should, and I would have to close the lecure and then re-open it and start from the point I left off at.

44. The eTEACH program is great in that it lets students watch lecture whenever they wish and go back over the material at any point. Also, the assessments, animations, and the general format is helpful. The potential downfall is students may put off watching the lecture every week on a regualar basis or can become easily distracted if they watch it, for example, in the dorm where interruptions may be common. Over-all, I feel that this is very promising and I enjoyed the lecture more than the two HDFS classes (362 and 363) at the UW I have taken as video courses.

45. I thought the web lecture was interesting. I think the ideas presented were very
    interesting, however it was sometimes hard to follow.......... When you are writing down
    notes from the slides it is also hard to try and listen at the same time. All in all I
    think it is a nice idea for certain situations but the live lecture might be a little bit
    easier to follow. Transitioning from one slide to the next didn't work either, I had to
    stop the lecture and start it up again at the same spot. That was kind of distracting,
    but i think i got the main point of the lecture. Very interesting. Thank you for the
    extra credit opportunity. It was really good incentive.