



Integration of Prerequisite Resource Materials in a Structural Design of Foundations Course Using Pencasts

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Integration of Prerequisite Resource Materials in a Structural Design of Foundations Course Using Pencasts

Abstract

As students enter the final year of an engineering curriculum, a large body of prerequisite knowledge is expected to have been mastered and retained. Knowledge of and proficiency in mechanics, structural analysis, and both concrete and steel structure design is typically required for success in senior level civil engineering design electives and capstone courses. However, students retain only some fraction of the material covered and proficiency gained in second and third year engineering courses as they progress to the fourth year. And the knowledge and proficiency retention level varies significantly from student to student. As technology available to higher education advances, and student comfort level with technology increases, instructors are making increased use of current technological devices. However, the efficacy and effectiveness of the technology is an important consideration that must be evaluated. The present study evaluates the effectiveness of pencast technology for civil engineering students in a structural engineering focus. Objectives of the study are to evaluate the efficacy and effectiveness of pencasts in CE441 – *Structural Design of Foundations*. This evaluation study is part of a larger, funded study to evaluate pencasts and other electronic media as archived resources for capstone students in all focus areas of civil engineering. Those who are interested in using online tools to deliver supplemental course materials may be interested in this paper.

Introduction

As students progress to their final year of an engineering curriculum, a large body of prerequisite knowledge is expected to have been mastered and retained. However, students retain only some fraction of the proficiency gained prior to their senior year. As technology advances, and student comfort level with technology increases, it is possible to increase the use of new devices to develop targeted, out of classroom study¹ and review modules for specific prerequisite skills. However, the efficacy and effectiveness of the new devices to accomplish the desired learning is an important consideration that needs to be evaluated.

The present study evaluates the effectiveness of pencasts for civil engineering students in a structural engineering focus. Pencast files can be archived for students in a number of formats on a variety of electronic platforms for viewing on a range of devices. The pencast files developed by the authors are most commonly distributed as a “talking PDF” that is essentially a video of electronic paper pages capturing an instructor’s writing and voice.

Students focusing in structural engineering typically enter a capstone with prerequisites of structural analysis, concrete structure design, steel structure design, and some experience with foundation design/engineering. The present study focuses on knowledge of both structural analysis and concrete design as prerequisite courses for CE441 – *Structural Design of Foundations*, also a prerequisite course for the structures capstone. This *Structural Design of Foundations* course has been the subject of a previous study² on effectiveness of a flipped classroom. The course has been taught by the first author for seven consecutive academic years covering nearly identical topics each year with consistent evaluation methods.

Background

The interest in adopting pencasts grew out of a number of issues common to many engineering courses – students are generally not enthusiastic about reading text books; students seem to be more inclined to use electronic media; large enrollment courses tend to limit opportunities for in-class interaction; and students tend to be reluctant to seek help with concepts that were likely covered in a prerequisite course. Properties of pencasts are unique and suited to addressing these issues.

Students' perceptions of using the pencasts as review or readiness for class is assessed formatively using pre- and post-online surveys and voluntary focus groups. The pre-survey targets students' prior experience with using supplemental, online materials and their perceptions of this experience. The post survey targets students' perceptions of using the pencasts throughout the semester; the behavior of use (number of times accessed, amount of time on task, repeated use of the same pencasts), and the value to students learning in the course. The focus groups help to obtain richer and deeper perceptions within a small group discussion.

Introduced in a *Structural Design of Foundations* course is a series of eight pencasts that review specific, isolated knowledge kernels in ten to fifteen minute segments. In addition to student perceptions, the study compares prior outcomes of the course on the basis of examination assessments and final grade performance to the same measures in the recent semester that included pencasts. The current semester course functions as in the past with the inclusion of pencasts.

Course Description

The civil engineering course, CE441 - *Structural Design of Foundations*, focuses on the non-geotechnical aspects of building foundation structural design. Covered designs in the course include steel base plates, pedestals, wall footings, concentrically loaded, isolated, square and rectangular footings, eccentrically loaded, isolated footings (square and rectangular) combined, isolated footings, mat or grid foundations, piles and pile caps, concrete retaining walls and abutments, flexible earth retaining structures, and caissons. Objectives of the course are to develop student proficiency in these foundation designs as well as develop a deeper understanding of general foundation structural design principles that will be applied to a range foundation types and unique situations later in their careers. The course could be considered fast paced with weekly, comprehensive, open-ended design problems.

- The course meets three times per week for 50 minutes over a 15-week fall semester for a total of 44 meetings.
- The course is a senior level elective that is a prerequisite for the structures focus capstone design course.
- The Fall 2013 class consisted of 8 women, 55 men, and 7 international students.
- Total enrollment of 63 students represents the largest since the course was taught due to a new prerequisite requirement to reach the structures focus capstone course.

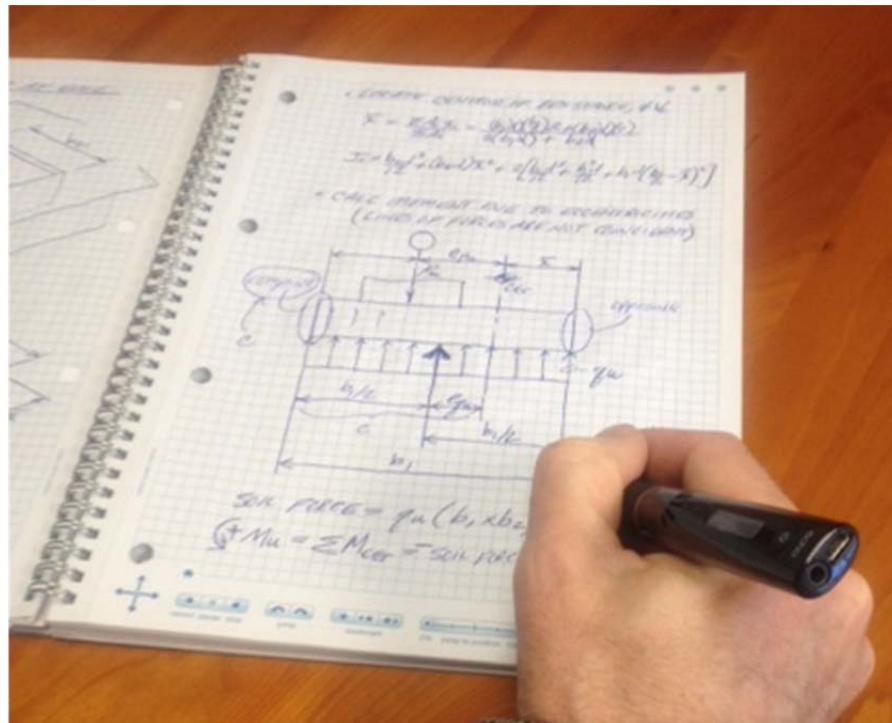
Why use a pencast?

A pencast is a digital version of notes and audio recorded as an interactive document³. Pencasts allow the observer to hear explanations and view material being written as a lesson progresses. A pencast digital file can be delivered via several media platforms including a pdf (see Figure 2), email, Evernote®, Facebook, Google™ Docs, Google™ Sites, Microsoft® OneNote®, and a proprietary website. Pencasts, on all platforms, can be paused, skipped ahead, skipped back, and visual material printed.

Pencasts are created using a “smart pen” (See Figure 1a)) that is slightly larger than a normal ballpoint pen and contains memory, a tiny screen, microphone, speaker, processor, video recording device, USB port, earphone jack, and an ink cartridge. The smart pen user must write on special “dot paper” (see Figure 1b)) that allows the pen to orient itself. The dots are practically not visible to the naked eye and give the dot paper a slightly gray appearance.



a) Smart Pen.



b) Writing with Smart Pen on Dot Paper to Create Pencast.

Figure 1. Smart Pen and Creating Pencast.

CE441_PileCapDepth.pdf - Adobe Acrobat Pro

File Edit View Window Help

Create [Icons]

42 (1 of 1) [Navigation] 71.9% [Zoom] [Tools] [Comment] [Share]

PILE CAP DESIGN

- V_u BETWEEN PILE ROWS IS CONSTANT
- V_u @ d AWAY FROM FACE OF COL. (B.P.)
- $\phi V_c = \phi 2 \sqrt{f'_c} b w d$ ←
- SET $\phi V_c = V_u \Rightarrow$ SOLVE FOR d
- $(h) = (d) + 6" \text{ EMBED} + 3" \text{ COVER} + \frac{d_b}{2}$
- 3" TOLERANCE

END OF PILE CAP

Figure 2. Pilecap Sample Screen Shot

Compatible Devices

Pencasts can be viewed on the several software platforms listed above by any device that can access these platforms. The authors have primarily utilized the familiar and robust pdf-based format (see Figure 2) that is also compatible with the university-wide course management system. Pdf files may be downloaded and viewed at anytime, anywhere. Based on a student survey and responses from a focus group students indicated that they primarily used laptops and/or desktop computers to view the pencasts. Additional detail regarding student preferences derived from student surveys is presented later in this paper.

Other devices that students found to be unsuccessful in displaying pencasts may not have contained the proper pdf reader software, however, the student pencast viewers did not pursue technical problems on individual devices as they had many options available to them and none were prevented from viewing the pencasts as needed.

Learning Objectives and Approach

Pencasts were developed based on instructor perceived needs of students and based on student requests. Pencasts 1 through 3 were prepared with instructor expectations that student review of fundamentals would be necessary to complete assigned design problems. As students became familiar with the pencasts, requests were much more common.

Topics of the eight pencasts provided are:

1. Shear and Moment Diagram Review
2. ACI Concrete Flexural Reinforcing Design
3. ACI Development Length Requirements
4. ACI Minimum Flexural Steel Requirements (student request)
5. ACI Reinforcing Bar Cutoff Requirements (student request)
6. ACI Two-way Shear for Interior Columns
7. ACI Two-way Shear for Edge Columns (student request)
8. Estimation of Pile Cap Depth for Initial Design (student request)

In an attempt to discover and evaluate changes in student performance as a result of the pencasts, average quiz grades and final course grades were compared to past semesters (see Figures 3 and 4). In both graphs the red line is the Fall 2013 course where pencasts were made available to students. The course is graded on a straight curve and has been essentially the same for all past semesters, taught by the same instructor, and all quizzes graded by the instructor. As can be observed from both graphs, there is no discernable change in quiz performance or overall course grade levels other than possibly fewer “C” and “D” grades. It may be that students who struggle more with the course benefitted academically from the pencasts more than those who are stronger. Also, the Fall 2013 cohort is the first where CE441 is a prerequisite to the structures capstone, therefore, a 30% to 40% increase in enrollment was observed. It may be that certain students have avoided this course in the past, preferring other electives and therefore skewing the results for comparison.

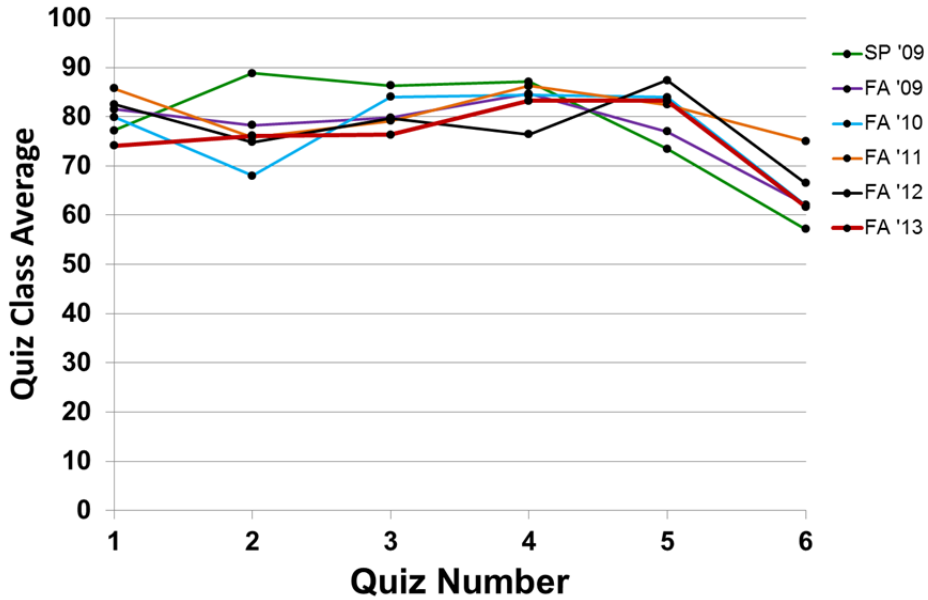


Figure 3. Comparison of Quiz Average Scores for Past Six Offerings.

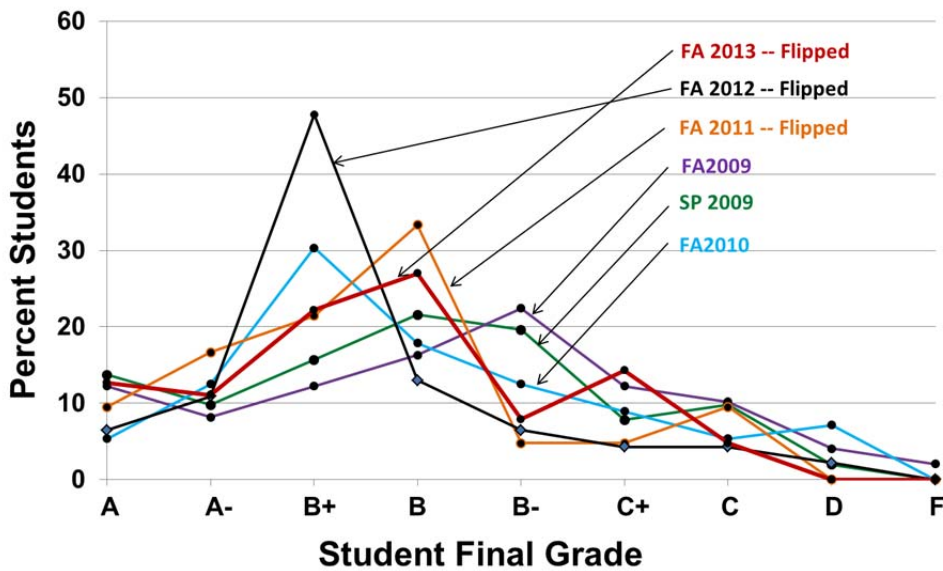


Figure 4. Comparison of Student Final Grades for Past Six Offerings.

Assessment Methods

Three assessment instruments were developed to determine students' perceptions of having access and value of pencasts as supplemental course materials. A pre-survey (see Appendix A) targeted students' prior knowledge and experience of using online course supplemental materials; a post-survey which targeted students perceptions of using the pencasts in this course; and a focus group which allowed for a face to face conversation with a small sample of students.

The focus group helped the research team garner students attitudes and deeper opinions to the learning experiences; asking ‘why’ questions in a safe environment.

Participants

All students enrolled in CE441 for the Fall 2013 semester were invited to access pencasts and participate in the evaluation of the pencasts. All students were fourth-year civil engineering majors, 55 male, 8 female, 7 international. The class was largely comprised of domestic students; however 10% (7) were international students. The students were recruited to participate during a regularly scheduled class period and signed informed consents as required by the university Office of Research Protections. Students consented to the use of their course materials, performance data, survey data and focus group comments for the purpose of the study. Participation was confidential. The instructional support specialist facilitated the focus group and summarized the data for the study which was not shared with the instructor until after grades were submitted.

Pre Survey

There were 34 pre-survey responses of 63 enrolled students, or 54% (see Table 1). This sample size was sufficient to gain a range of experiences and input from the students. Most useful to the authors was: 1) the enthusiasm with which the students accepted pencasts; 2) that students primarily used notebook computers to view the pencasts: and 3) that such a large percentage found the pencasts most helpful for design problem preparation (pre-homework review).

Table 1. Pre-Survey Summary Results.

Topic/Question	Response
Have used online resources	94% yes
Types of online resources used	82% Videos, 18% Pencasts
Pencast duration preferred	6-8 min 38%, 8-10 min 50%, 10-15 min 12%
Played pencast more than once	88% yes
Devices preferred for pencast view	6% phone, 9% tablet, 85% laptop
Pencast most helpful for what course activities	88% lecture support, 41% reading/textbook support, 71% post quiz review, 97% pre-homework review

Additional student suggestions and observations from the pencast pre-survey are summarized as follows:

- Allows explanation without class time constraint
- Good for basic concepts
- Allows students to learn at a pace student can control
- Put them on YouTube
- Provide a weekly pencast that covers the week in 10-15 minute video

The authors were interested in how to condense three lecture periods into a 15 minute penecast.

Post Survey

There were 63 post-survey responses of 63 students or 100% due to an incentive for full participation (see Table 2). The authors were again encouraged by the willingness of students to access the penecasts and use them as course resources. Of interest in the post-survey was: 1) the reduced penecast duration preference to 6-8 minutes; 2) the continued and increasing use of notebook computers over other devices; and 3) the change in course activities that were most supported by the penecasts.

Table 2. Post Survey Summary Results

Topic/Question	Response
Access penecasts during semester	91% yes
Length of time preferred	58% 6-8 min, 39% 8-10 minutes, 3% 10-15 min
Use PDF printing, pause, or slide bar	85% yes
How often did you access a penecast?	79% 1-2 times, 15% 3-4 times
What devices did you use to view penecasts?	18% smart phone, 5% tablet, 97% laptop
What device do you prefer to view penecasts?	2% smart phone, 2% tablet, 95% laptop
What types of graphics do you prefer?	51% freehand, 19% computer, 29% no preference
Which course activities?	76% lecture support, 24% reading, 14% post quiz, 73% pre-homework

Focus Group Results

Students who participated in the focus group indicated that they liked having access to a penecast. They were happy that the penecasts were readily accessible, could be used for study, review or pre-class prep. The students liked the efficiency of being able to view selected segments or an entire penecast. They recommended that the option to use a penecast be voluntary and as a supplement to course material. Interestingly, the students all agreed that they would prefer a penecast over an entire video that they would be required to watch from beginning to end. They had previous experience in another course which used out of class online videos as supplemental material, which they thought was not a good use of study time because the video had to be viewed from beginning to end. In the focus group a student commented “I liked the penecast because you could see what you want to, when you want to, and skip through.” Another student added “It’s nice to go back and look at something that you took notes on in class and need to see again.” To this a student also said “If you miss one little thing in class...you can easily go through it [the penecast], stop and listen as many times as you want.”

The students all agreed that the efficiency and ability to skip forward and back was very useful. Students agreed that the penecast, being voluntary and flexible, respected their individual learning and study styles because they could go right to a particular spot and pick up where they left off.

The students agreed that the pencasts kept them organized; they were voluntary; that you could watch before class to be better prepared; and that “you have a resource that you can watch ‘a million’ times if you want, so if you don’t get it, you can go back and forth.”

As a suggestion a student quipped “If he [the professor] said ‘watch this 10 minute pencast before you come to class and you will be better prepared for what I am going to talk about’. I would have been more willing to watch them.” This made the focus group participants chuckle!

Some suggestions for future use were to provide pencasts that would target specific items for a pre-class assignment from the readings, such as “if you want to be better prepared for the next class, watch the pencast”. The researcher believes that the students want to have a pencast that would replace the reading assignment. Another constructive comment came from a student who had experience in a flipped class that used online videos as pre-class preparation, “In the past I was in a flipped class where you had to watch a 30 minute online video. This [the pencast] was so much nicer because you could pause it, go back and watch whatever you needed.” When asked about technical problems, these students said they used their notebook computers to view the ‘talking PDFs’. While some had tried tablets or iPads the notebook on a high speed connection was most successful. They would prefer the large screen of the notebook compared to the smaller viewing space on other devices. The students all agreed that the best pencast is 10-15 minutes long, kept to the point, did not lose their attention, and the professor would draw while speaking. It was unanimous that there should be more pencasts!

Summary and Conclusions

Electronic media as a resource to students in a senior level CE design course was studied relative to student interest, performance, and recommendations for future electronic media. The electronic media studied is what is known as pencasts, or “talking PDFs”. By a wide margin, students were very enthusiastic about the pencasts, made use of them, and preferred pencasts over videos due to the ability to print, skip ahead, and skip back. Students found the pencasts useful for pre-class preparation, quiz review, and homework completion. Further study is required to evaluate whether student performance is improved through the availability of pencasts.

Bibliography

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2. Laman, J.A. and M.L. Brannon, "Phase-In of Classroom Flip in the Redesign of a Senior-Level Engineering Course and Outcome Comparison to Previous Version of Course," ASEE Annual Conference Proceedings, San Antonio, Texas, June 2012
3. <http://www.nytimes.com/2013/12/19/technology/personaltech/review-the-livescribe-3-pen.html>

Appendix A – Pre-survey items

Pencast Project pre-survey FA2013

Regarding your experience using the pencasts at this point in the course please answer the following questions.

Prior to this course, have you had the option to use online resources?

- Yes
- No

If yes, what type of media did you use?

- Videos
- Pencasts
- Other _____

What time length for an online tutorial is most suited to your leaning?

- 6-8 minutes
- 8-10 minutes
- 10-15 minutes

When viewing a pencast would you most likely pause throughout the program?

- Yes
- No

Would you expect to play a pencast more than once?

- Yes
- No

Would a pencast be more useful to you if it were in a format that is compatible with a range of devices?

- Yes
- No

What devices do you currently use? Check all that apply and include the make in the text field.

- Cell phone _____
- Tablet _____
- Laptop _____
- Other _____

If the pencast is viewable on cell phone, tablets or other devices which would you prefer to use?

- Cell phone
- Tablet
- Laptop
- Other _____

Would you prefer more or less graphics imbedded in a pencast?

- More
- Less
- Does not matter

What types of graphics would you prefer?

- freehand
- computer generated
- No preference
- Other _____

Which course activities are pencasts most helpful to you? Check all that apply.

- lecture support
- reading/textbook support
- post quiz/exam review
- pre-homework/design problem review
- other _____

Would a supplemental worksheet help you when viewing a pencast?

- yes
- no

Was the pencast demo that Dr. Laman used in class helpful for you to understand this tool?

- Yes
- No

Are you likely to request a pencast on a specific topic in the future?

What can we do to make the pencast tutorials more appropriate for your learning?

Appendix B - Post-survey Items

Pencast Project post survey FA2013

Regarding your experience using the pencasts in CE 441 this past semester please answer the following questions.

Prior to this course, have you had the option to use online resources?

- Yes
- No

If yes, what type of media did you use?

- Videos
- Pencasts
- Other _____

Did you access any pencasts during this semester?

- Yes
- No

What time length for a pencast tutorial is most suited to your leaning?

- 6-8 minutes
- 8-10 minutes
- 10-15 minutes

When viewing a pencast did you make use of the features such as pdf printing, pause, slide bar to go back or forward?

- Why? _____
- Why not? _____

How often did you typically access each pencast?

- 1-2 times
- 3-4 times
- More than 4 times
- I did not access them.

What devices did you use to view the pencasts? Check all that apply.

- Smart phone
- Tablet
- Laptop/desk top computer
- Other _____

What device did you prefer to use most of the time?

- Smart phone
- Tablet
- Laptop/desk top computer
- Other _____

What device did you use least of the time?

- Smart phone
- Tablet
- Laptop/desktop computer
- Other _____

Would you prefer more or less graphics imbedded in a pencast?

- More
- Less
- Does not matter

What types of graphics would you prefer?

- freehand
- computer generated
- No preference
- Other _____

What were the benefits of having the pencasts available as the semester progressed?

Which course activities were pencasts most helpful to your learning? Check all that apply.

- lecture support
- reading/textbook support
- post quiz/exam review
- pre-homework/design problem review
- other _____

In this class...

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
I sought help from my instructor/TA more often than in other classes	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I sought help from my peers more often than in other classes.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I attend class more regularly as compared to my other classes.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Having the pencasts made me more responsible for my own learning.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Having the pencasts helped me to be more successful on class assignments.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Did watching the pencasts help your understanding of the course concepts?

- Why? _____
- Why not? _____

What additional subject(s) would be better understood if pencasts were added?

What did you like least about using the pencasts?

What suggestions do you have to improve pencasts for future students?

Appendix C – Focus Group Protocol

Focus Group Protocol -Perceptions of Student Learning

The purpose of the focus group is to discuss how participation in the pencast tutorials has been beneficial to students. In other words, how you see using these tutorials outside of class are beneficial to you.

1. To start off this conversation, I'd first like to know how you came to participate in the project.
 - a. State name, major
2. In general, tell me your thoughts about the pencast tutorials.

Regarding learning effectiveness:

1. Did you feel that the pencast tutorials helped with your learning of the course material? Can you please explain your answer?
2. Did you feel that the pencast tutorials helped you to be better prepared for the upcoming class meeting? Can you please explain you answer?
3. Did you feel that the pencast tutorials were a useful to you? Can you please explain your answer? If not useful, why?

Regarding usability of the tool:

1. Did you feel that you that the pace of the pencast tutorials were too short, too long or just about right for your listening? If not, how much time would you need and why?
2. Did you use the pause, go back and go forward features? Can you explain how often you might have used these during a tutorial?
3. Can you explain any issues you may have had with the written words? The audio? The download of the pdf?

On the quality of the assignments:

1. Do you believe that the pencast tutorials were beneficial to your learning in the course? Please explain your answer. How?
2. What is your impression of having the option of doing pencast tutorials as a method to prepare or review for class?
3. Can you please tell us how we can improve on the pencast tutorials?

Other comments that you would like to share with the group? Thank you for your time.