AC 2009-1239: THE EFFECT OF ON-DEMAND INSTRUCTIONAL VIDEOS ON MEDIUM-TERM RETENTION OF MECHANICS SKILLS

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The Effect of On-Demand Instructional Videos on Medium-Term Retention of Mechanics Skills

Abstract

Recent experience with on-demand instruction via web-based videos indicates some correlation between video use and student performance in same-semester graded events (Klosky, Bruhl and Bristow, 2008[1,2]). A key question remains: does including these on-demand videos improve student performance and retention in the longer term? This paper concludes that the videos have a positive effect on student retention, and addresses the effect of these same videos on the medium-term retention (semester to semester with a summer break between) of basic task knowledge in fundamental areas of mechanics, such as production of shear and moment diagrams. The basic mechanism used to evaluate the effect was the actual versus the predicted performance of the students on two events: an ungraded written evaluative event conducted on the first day of class in the fall. This performance was cross-indexed with video use, which was tracked automatically via the website serving the videos in the previous spring semester. Grades will be predicted using a model established by the authors and presented previously (Bruhl, Bristow and Klosky, 2008[3]). Rigorous statistical analysis was undertaken to establish the efficacy of the videos and the probable positive effect of those videos on student performance of basic mechanics tasks. Recommendations are presented related to the implications of these findings and the best practices for the use of on-demand video instructions.

Introduction/Background

The presence of short, high-impact videos in the entertainment marketplace is now ubiquitous, and many engineering students are highly comfortable with that format. However, university educators have been slow to adopt this format for the propagation of knowledge. Nearly all engineering educators continue to prefer the familiar "push" format as compared to the more difficult-to-manage provision of "pull" content that can be absorbed by the student at any time according to their needs (Klosky et al., 2008[2]). It is certainly true that a lot of highly varied content is now much easier to sort and more widely available than previously, and that content is growing very quickly; witness, for instance, MIT's OpenCourseWare initiative, which is piling enormous amounts of course material onto the internet. This content, though, is mostly relatively traditional (Boroughs, 2009[4]) and not specifically tailored as supplemental material intended to enhance student comprehension. The authors made an extensive search of the internet, and from our observations, it remains true that the majority of the video content available for student consumption in all venues, not just OpenCourseWare, is simply recordings of the traditional lecture-style presentation posted to the web.

In 2007, the authors set out to determine whether short, highly-focused, instructor-made videos could be used to improve student comprehension and performance in a basic course in Statics and Strength of Materials (Statics-Strengths). An in-depth study of the effectiveness of this instructional method, labeled Video AI (for Additional Instruction) was undertaken, and the conclusion was that the introduction of such content did marginally improved student performance[1, 2, 3]. The creation and use of these videos as well as extensive commentary and lessons learned are contained in previous papers by Klosky, Bruhl and Bristow[1,2,3]. This paper addresses a follow-on question; does including these on-demand videos improve student performance and retention in the longer term? To investigate this hypothesis, Video AI was made available in Statics-Strengths in the spring of 2008, student use was tracked, and a simple evaluation instrument (quiz) was deployed at the beginning of Mechanics of Materials (Mechanics), which was taught in the fall of 2008 as the follow-on course to Statics-Strengths. Of particular interest was student retention of basic concepts and their ability to perform computations demonstrating those concepts, enumerated later, for which supplemental videos had been available in Statics-Strengths and which were critical to the understanding of mechanics. In an extensive review of available literature on students' long-term retention of various skills, the American Educational Research Association[6] found that instructional techniques can have a profound impact on retention. In particular, techniques which allowed students to actively pursue knowledge tended to yield improved retention of knowledge after the end of the course, even when they did not lead to significant differences in performance at course end. In this study it was hypothesized that Video AI, which allows students to control the pace and timing of their instruction, would yield improved retention of course concepts among students who used it.

This paper will describe the methods used to evaluate student retention, the effect of video instruction on that retention rate and possible rational for the observed difference in retention. Recommendations on best practices for the implementation of additional video instruction are then presented This paper will not describe in any detail the predictive model used to project likely student scores or the format and use of the video instruction. That information is available in previous publications[1,2,3].

Measuring Student Retention; The Evaluative Instrument

For this study, the authors set out to make a quantitative rather than qualitative measure of term-to-term student retention rather than gathering anecdotal or qualitative data. To accomplish this, students' medium-term retention of the material covered in Video AI clips was measured using a short quiz given the first day of the Mechanics class, which most students take one semester after the Statics-Strengths class. This quiz, presented as Figure 1, contained three simple application problems that are essential to Mechanics and for which Video AI clips had been available in the previous semester. The problems required students to find the centroid of a compound shape, solve a two-dimensional equilibrium problem, and construct the internal shear force and bending moment diagrams for a beam under a distributed load. The students were given ten minutes to complete these problems; students were not permitted to use old course notes or given advance warning of the quiz. This approach allowed instructors to gain insight into the students' mastery of critical skills from the prior class, which for most students ended three months prior (the length of the summer break between semesters).

The problems on this quiz were weighted equally and assigned scores between zero and two points each, depending on the correctness and completeness of the solutions. The grading rubric assigned two points if the student demonstrated a clear understanding of the topic and an ability to perform the calculations required without major errors, one point if the student demonstrated a a rudimentary but incomplete understanding of the topic and no points if the student clearly did not recall the key concepts (usually characterized by a blank sheet). Thus, total scores for the quiz ranged between zero and six points. All students enrolled in the Statics-Strengths and Mechanics courses were given the opportunity to take the quiz, which earned them bonus credit. We then analyzed retention of Video AI concepts only for those students who had previously taken the Statics course and for whom performance and Video AI access data were available. In total, medium-term retention was analyzed for 113 students, most of whom were third-year engineering majors at the time that concept retention was assessed.

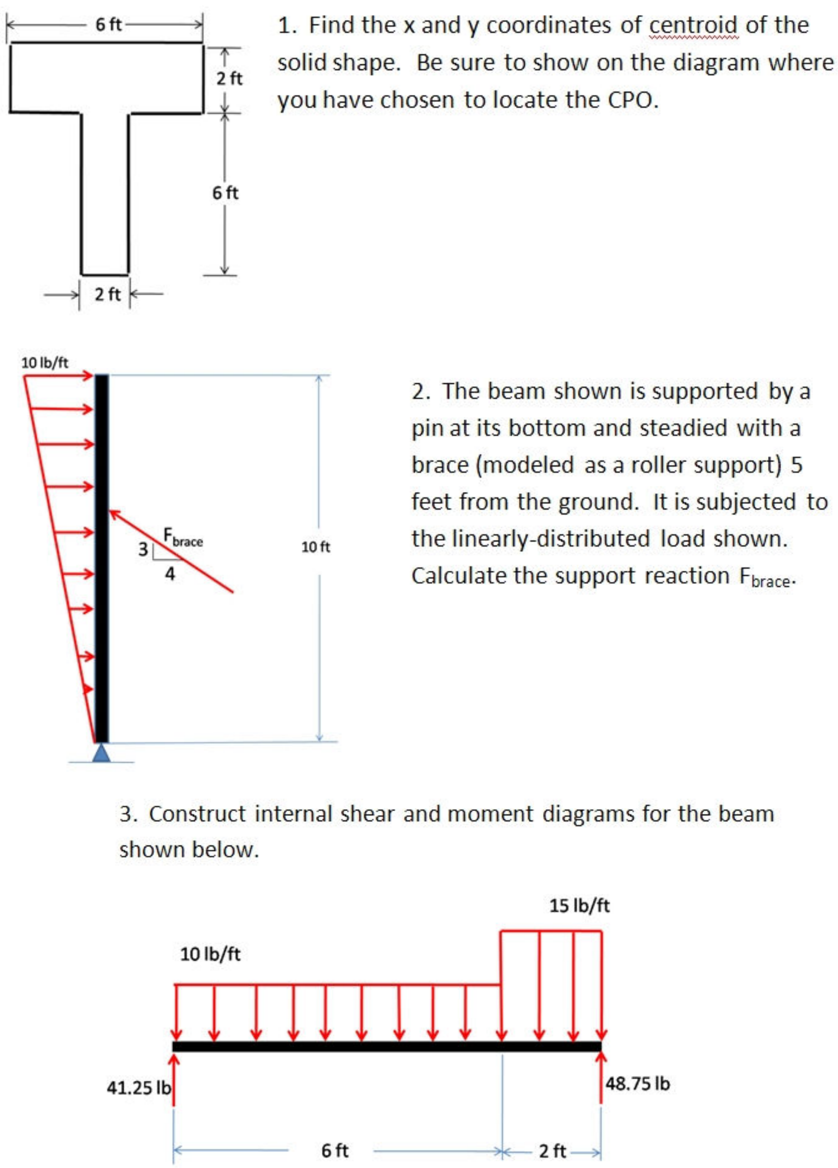

Figure 1: The Quiz

Predicted versus Actual Retention

To measure the student retention, it was necessary not just to measure student performance on problems from Statics-Strengths, but to correct that performance to normalize for the raw capability of each student, similar to the method suggested by Klosky et al. (2006)[5]. Thus, a student who earned an A in the course but earned a B on the retention test related to that course would be considered to have underperformed, while a normally C student who earned a B would have overperformed. To make this correction, student performance was predicted as a function of their original grade in Statics-Strengths; in other words, continuing mastery of the course material was modeled as directly related to the students' original mastery of the material. Thus, to compare a six-point quiz to a course grade based on 2000 points, the Statics-Strengths course grade for each student was normalized to a six-point scale, yielding the predicted grade, *PD*. The quiz grade, *QG*, was then subtracted from the predicted score *PD* to provide a numerical measure of students' change, Δ, in mastery of the material over the elapsed time. This computation is summarized below in EQN 1.

$$QG - PD = \Delta \qquad \text{EQN 1}$$

The results of this analysis can be seen in Figure 2. As expected, most students lost considerable mastery of critical skills over the three months between evaluations. On average, students

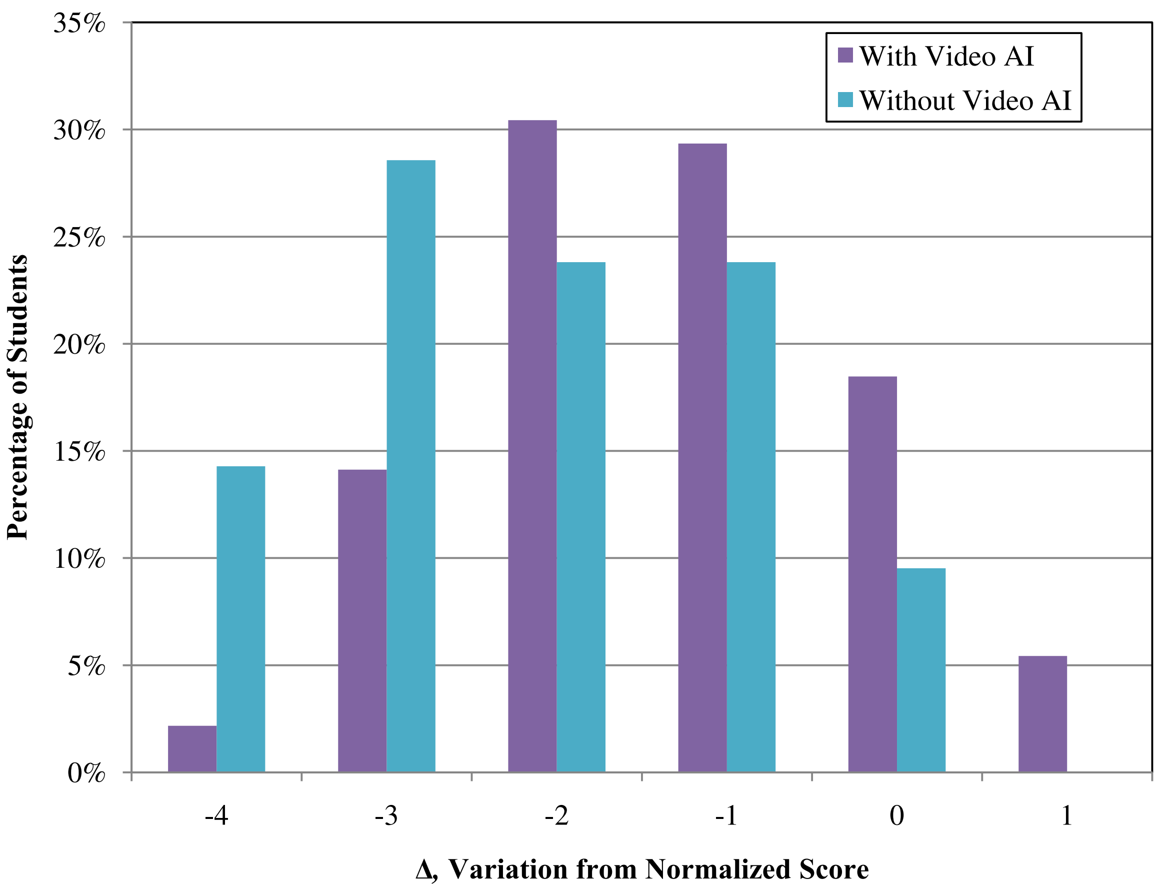

Figure 2: Variation in Student Performance

performed 33.9% worse than their course grade predicted, though the evaluative event could be classified as relatively easy. Students who had used Video AI in the Statics-Strengths course experienced considerably less skill atrophy than average; on average, these students performed 31.5% worse than predicted by their Statics-Strengths course-end grade, while students who did not use Video AI performed 44.3% worse than predicted by their course grade. The standard deviation of all students' change in performance was 19.7%, and the standard deviations within the groups were not significantly different from that of the overall data set. This strongly indicates that student performance was higher among those students who watched instructional videos in the spring session of Statics-Strengths.

Lessons Learned: What Does it All Mean?

Student retention between semesters has long plagued engineering faculty, causing many to lament that the students simply remember nothing semester to semester and must be taught the key topics anew in each course. This data does little to argue against that lament, and the overall data certainly suggest that student retention of the most basic topics is poor. This suggests that we should be employing every trick in the book to improve student retention, as poor early-semester recall and performance poses a major hurdle to continued learning and general academic progress. There are, of course, a wide variety of techniques that can be employed to assist with this, with student practice of rusty skills via early-semester graded events being a tried and true tool.

That said, this study hints strongly that viewing the Video AI clips was a predictor of better student retention, with Figure 2 clearly illustrating the contrast between those who made use of the supplemental information and those that did not. The shift in the distribution in the positive direction certainly indicates that those who did view the videos were more successful in retaining the information. However, the principle weakness of this study lies in the reason *why* watching videos leads to this change. For instance, students who watched the video may have simply been more motivated ("I watched the video because I want to know everything about the topic!") or more conscientious ("I watched the video because my instructor said they were good for me, like eating my spinach!"). Considerable further study would be required to tease out the actual causative relationship between improved performance and watching Video AI.

Best Practices for Providing Supplemental Video Instruction

In creating the short videos that made up the Video AI library used in Statics-Strengths, we learned a lot. During the trial period, we evolved the following basic rules:

1. Short; the videos should look a lot like what you might see on YouTube. Longer videos were not popular with students.
2. Focused on a specific topic; allows the student to get what they want when they want it without sifting through a lot of unwanted content.
3. Address common problem areas or topics; instructors know which areas confuse their students. Focus the effort on putting up videos that address know trouble spots.
4. Walk through example problems; avoid long theoretical discussions which are probably better for the classroom. The video format is better suited to active things like problem solving and demonstrations.

5. Keep them "real"; avoid the temptation to edit and perfect the content. Voltaire said "The perfect is the enemy of the good", and that certainly applies in this case. It could even be argues that much of the appeal of YouTube is in peoples errors; in watching those clips which are popular in general, it is apparent that perfection is boring.
6. Don't add to the instructor's workload.

These videos can be easier to create than written solution if done right. We used the following resources to create the videos:

- Tablet PC; you can write directly on the screen as if on a piece of paper
- Windows Journal Writer or similar (program included in the purchase of a Tablet PC)
- Desk microphone; we used one that is included with the purchase of a desktop PC, but a higher-quality microphone would no doubt improve the quality.
- Camtasia 4.0 software or similar

Camtasia is a simple program to use. Creation of the video requires the user to select the portion of the screen to be recorded, perform a quick audio check to ensure microphone functionality, and press the record button to begin screen and audio capture. When capture is complete, the user presses the stop button, and Camtasia opens the editing window, in which other videos, PowerPoint, or audio files can be added and edited similarly to typical digital movie editing software. Once the user is satisfied with the product, the video is "produced" into formats of the user's choosing. Professors at other institutions have produced similar videos by videotaping working problems on a chalkboard9 or Tablet PC10. We have not found any need for editing. If there are minor errors that the instructor corrects while making the video, we do not believe the time necessary to edit them out is warranted. We have approached this project with the idea that the videos need to remain "real" and not "sterile." Using the instructor's own handwriting and retaining minor mistakes maintains some of the "realness" of the video and makes it more interesting to watch. Some of the videos were made by writing on a blank piece of virtual paper, which resulted in a viewing experience similar to watching a problem unfold in class on the chalkboard. Other videos were made by capturing the instructor using more "finished" products like PowerPoint or Word documents to create the solutions. As time is always limited, there are no pedagogical reasons to use PowerPoint or Word over a blank screen for most applications.

Effort was made to ensure that each video was less than ten minutes long. The primary reason for this limit was to keep videos short enough that students will be willing to use them: too long, and the student is less likely to take the time to find needed content in the video. The time constraint also forced the instructor to whittle the information down to the absolute essentials, reducing the extraneous details often included in classroom discussion. Another reason for this limit is that these videos are intended to supplement typical classroom activities. We do not want the videos to replace the need for active participation in class. To enable and encourage working ahead on problem sets, videos should be posted as early as possible in the semester. As long as the videos do not show the same problems that are worked in class, there is no pressing pedagogical reason not to post all of the videos at the beginning of the semester. This allows students to see the resources that are available, gives a preview of what is to come, and may satisfy global learners' desires to see the big picture earlier. Of course, as the semester progresses, other content areas may appear that could easily be addressed by a quick video. In that case, create the video, post it, and announce it to the students. This demonstrates a number of positive principles to the students: the instructors are receptive to student needs, the instructor cares about student learning, and every group of students is different (what may not have been a problem for some students is a challenge for others).

Conclusions

The use of short, simple, focused videos appears to improve student retention of simple topics in statics and strength of materials semester-to-semester. These videos are a resource that students like to use: the videos make use of technology which students use in other aspects of their lives and are, therefore, very comfortable with. Further, Video AI is positively regarded by students[1,2]: they like having the resource available, and it improves their learning and retention. We are excited to see how it continues to evolve and improve the education of future engineers.

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