AC 2008-1286: ON DEMAND LEARNING - AUGMENTING THE TRADITIONAL CLASSROOM

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On-Demand Learning – Augmenting the Traditional Classroom: Details on the Effectiveness of Short, Simple, Instructor-Made Videos in an Engineering Course

Abstract

In the spring of 2007, short, focused, instructor-made videos intended to supplement classroom presentations were successfully incorporated as an additional learning resource in the last half of a fundamentals of engineering course at the United States Military Academy. Based on the success of this introduction, the use of these videos was dramatically expanded in the same course for the Fall 2008 semester. A detailed study of the effectiveness of this resource was undertaken, and this paper reports the effectiveness of this resource on academic performance and student perceptions of learning. We discuss usage trends and preferences throughout the semester as students discovered and acclimated to having additional instruction available whenever and wherever they were studying. The paper also discusses the usage of the video resource based on learning styles and previous academic performance. It is clear that visual or sequential learners are not the only ones who like this resource; the videos were equally used by global and verbal learners. Another concern addressed is the hypothesis that growing the use of video will lead students to abandon textbooks and other traditional resources in favor of watching videos and "pattern matching." This concern proved invalid during the semester – students still used multiple resources to study and prepare assignments, including their textbook. The observation from Spring 2007 that watching these videos improves students' perception of learning as well as their academic performance was corroborated on a broader scale in Fall 2008. The academic benefit is quantified using a predictor of performance based on students' grade point average at the start of the semester. It is shown that those students who made use of the videos improved their academic performance as compared to those who chose not to use the videos. The authors conclude that significant benefit can be gained by creating and posting short, simple, instructor-made videos.

Introduction

Dramatic and continuing improvements in internet availability, connection speed, and computer technology have led to a change in the way many people receive information. In the pre-internet world, people had much less choice in how they gathered information; it was a "push" world. That is, information was pushed to the people through newspapers, television and other limited outlets. If you wanted to see a movie, you went to the theater where a movie that a remote producer had decided months ago was "right for The People" was scheduled. If you wanted to learn of the news events of the day, you tuned in to the appropriate channel at the scheduled time and received what the stations had programmed. Newspapers allowed people to "pull" some information as an individual scanned for items of interest, unlike the broadcast news, but the choice and content richness were limited by the format.

Along came the VCR; people could now watch a movie they wanted when they wanted. With a VCR a person could also now record television shows or news broadcasts and watch them at a time that was more convenient. The world was shifting to a "pull" environment. The introduction of the DVD provided more information than just the movie itself and allowed us to now watch movies on a laptop computer or portable DVD player increasing the flexibility of watching what you want, when you want, and now *where you want*. TiVO has made *watching what we want when we want* even easier, and the sudden growth of internet-based, on-demand video has been nothing short of phenomenal.

As capabilities and use of the internet expanded, it became possible to pull information and entertainment at will. The traditional concept of the media shifted dramatically as television stations created websites that augmented – and in a few cases replaced – traditional broadcasts. People now access news and entertainment whenever they desire. The "pull" world is here.[1] People use their personal computers, iPods, and even cell phones to pull the information they want and listen or watch it whenever and wherever they want, and no generation is taking advantage of this more than today's youth.

Education, however, still primarily occurs in a "push" environment. Students show up to the appointed classroom at the scheduled time and the professor decides what information they need to receive during that lesson. This is augmented by textbooks (arguably a "pull" resource), but the subject matter covered is certainly being pushed by the professor. Yet, today's students pull information in nearly all other aspects of their lives, which raises a question: *can professors implement resources in their classes that follow the "pull" model, and will these resources be measurably effective?*

This paper argues the answer to the question is a resounding "Yes!" The data and analyses presented here strongly indicate that by providing a reservoir of short, instructor-made videos to students, both academic performance and student perceptions are positively affected. More specifically, this paper presents an analysis of event and course grades to measure the academic benefit of short, instructional videos used to augment traditional classroom instruction. Also presented is a discussion about the impact of learning styles on the likelihood that a student will make use of these videos. Finally, student feedback about the resource is summarized, common faculty concerns are addressed, and ideas for the future of engineering education are proposed.

Background

The current generation of college students has literally "grown up" with computers and communication technology. Our students have been described as "digital natives" and the rest of us are "digital immigrants"[2]; essentially, older people are still learning the language. "Computer games, email, the Internet, cell phones, and instant messaging are integral parts of their lives" and they "think and process information fundamentally differently."[3] In a presentation to the Metro New York Library Council, Lee Rainie, the Director of the Pew Internet and American Life Project, showed how dramatically technology has evolved during the digital natives' lifetime. When they were born (c. 1985), the personal computer was already ten-years old. When they were in Kindergarten, Tim Berners-Lee wrote the World Wide Web program. Palm Pilots were released to the market when the digital natives were in middle school and Napster, Wikipedia, blogs, and iPods appeared when they were in high school. Since they have been out of high school, Skype, podcasts, and YouTube have been created.[4] What has taken those of us in other generations time to learn, adapt to, and integrate into our lives and work have been a part of everyday life for our students.

Today's students "rely on the Internet to help them do their schoolwork" – they use it to do research, correspond with classmates, share tips about assignments, communicate with teachers, use websites pointed out by their teachers, and participate in online study groups.[5] In 2002, 78% of children between the ages of 12 and 17 reported using the internet[6] (this is now the population in college and it is reasonable to assume that this percentage has increased in the past 5 years). In 2005, 31% of online teens reported downloading videos so they could play them at any time[7] and 29% of owners of iPods or MP3 players reported downloading podcasts for listening at their leisure[8]. When comparing podcast interest over the span of February to August 2006, the increase is striking – 14% of internet users ages 18-29 in August compared to 10% in February[9]. These statistics strongly support the growth of the "pull" environment. Further, by the time this article is published, nearly all of these figures will be considerably out-of-date. However, there can be little doubt about the fact that nearly all types of internet usage will grow, not shrink.

As portable audio and video players become more prevalent and popular, wireless internet accessibility becomes commonplace, and the use of these technologies by students increases dramatically, teachers seek ways to incorporate them into education. It is indisputable that our students use podcasts and downloaded videos regularly. It is also clear that our students are savvy users of the internet and expect to use it to complete course requirements and/or generally enrich their educational experience. Given this, we owe it to our students to develop content that makes effective use of technology with which they are comfortable. Further, we must provide it in a format that is interesting and applicable to them, and meet them – to some degree at least – in their "world".

Podcasts are audio-only presentations and have been used in courses at many colleges and universities for several years– the most well-recognized study was Duke University's integration in 2004 of podcasting across its campus[10]. Stanford University also completed a high-profile study of iPod use in the classroom[11], professors at Bryn Mawr College have used podcasts in their courses[12] as have several professors at the University of Wisconsin[13], to name but a few of the examples of educators integrating this particular emerging technology into their courses. Significantly, in most cases the iPod is used to capture audio content from lecture or discussion and make the recordings available to students. A scan of ed-cast.org[14], a repository for pod- and videocasts in higher education, shows 41 podcasts listed: 28 are lectures or presentations and the other 13 are interviews. This is in significant contrast to the popular site YouTube, where the vast majority of the videos are less than five minutes long. Further, it indicates that many choose not modify their content style when transitioning to a radically different format. This is certainly not due to any malice, but instead to significant barriers of knowledge and time.

Podcasts should not be viewed as a way to replace existing ways to get information (reading, listening to live presentations, etc) but rather can augment them, providing students with another resource to assist their study. Positive implications of the use of podcasts within a course include: helping auditory learners and non-native speakers, providing a way for students to review material other than their notes (and in accordance to their own schedule), or providing content not presented in the classroom (a "supplement").[15] Students who are absent can also benefit significantly from hearing and seeing an explanation rather than simply reading the notes of another or the textbook.

Podcasts are becoming common in humanities courses – especially foreign language and music courses where the application is well suited to assist learning of vocabulary or studying various compositions. The uses of podcasts in math, science, and engineering courses are not as obvious and have, therefore, seen minimal inclusion in such courses. For example, a recent scan of Merlot.org[16], a repository of educational resources, turned up 65 podcasts – only 12 of which are related to math or science and none are for an engineering discipline – and 733 videos. 247 of the videos are for math or science and 17 are for engineering. During the 2004 Duke study, only two science or engineering courses used iPods and in both instances the iPods were used to capture and/or playback audio for a laboratory experiment. At Bryn Mawr, iPods have been used to record lectures and pre-lab information in science courses.

To date, many of the uses of vodcasts, which include both sound and video, in higher education simply add an instructor's face to what can be heard on a podcast. In many cases, a slide show is narrated. Over half of the videos found on Merlot.org are lectures and range in length from 30-minutes to one hour. Some instructors[17,18,19] have used video cameras and document cameras to create shorter (5 to 10 minutes) videos focused on specific topics or example problems. The challenge for instructors within technical disciplines is to make better use of this educational resource. As screen capture and video editing software continues to become less expensive and simpler to use, the opportunity for incorporating higher quality vodcasts of greater variety into a course is great.

The Use of Videos in an Engineering Course

Noting the trend toward "pull" resources and acknowledging that our instruction is primarily "push", we looked to the example of the typical (if there is such a thing) video on YouTube and decided to create a few short (5-10 minutes) instructional videos to provide additional instruction on commonly confounding topics in our introductory engineering course, Fundamentals of Engineering Mechanics and Design. The course provides instruction in statics and mechanics of materials with the focus of the applications on axial members, beams, columns, and torsional shafts.

We termed our new video learning resource "Video AI" ("AI" stands for "additional instruction.") The initial implementation began midway through the Spring 2007 semester and was very successful.[20] We had three guiding principles in creating the vodcasts: they must be short, they must be focused and they must be very simple to produce. The last was particularly important, as we did not want to overburden the instructors involved in the project.

Noting a promising improvement in academic performance and student perception of learning during the initial trial, we quickly decided to comprehensively implement instructional vodcasts for the Fall 2008 semester. We created short videos for each major topic in the course; roughly 25% of these videos discussed concepts in general terms and the remaining 75% showed example problems being worked with the instructor speaking as the screen displayed the written work; this is very similar in appearance to distance learning classes conducted with a microphone and document camera. The videos were short and focused on a single topic. As much as possible, the videos show concepts or work examples in a way that differed from the textbook or the class description. Additionally, to conserve instructor time, we did no editing of the videos.

To assess the effectiveness of the videos, usage data was gathered using the Blackboard site for the course. Blackboard allowed for the tracking of how many times each student accessed each video. This usage data, combined with achievement on various graded assignments, enabled an analysis of how individual performance was impacted by these videos. This "self-selection" into groups (students who used the videos and students who did not) prevented us from comparing aggregately how videos improve academic performance. 113 of 183 cadets in the course accessed at least one video one time. We administered a survey at the start of the semester to gage perceptions about the program and determine their previous experience with similar resources. We also asked targeted questions on our end-of-course survey to assess student opinions of videos as well as student beliefs related to the videos and their effect on learning.

Findings

Video AI clearly has a positive modest impact on academic performance. In order to quantify this benefit, we predicted each student's performance in the course based on their GPA coming into the course. 97% of our 184 students were first semester juniors, so they had at least four full semesters of grades accumulated in their QPA. Further, the highly homogeneous undergraduate experience of our students ensured small variations in preparedness among the study population. The remaining students were first semester sophomores. Those students who watched the videos as part of their study performed on average 2.3% better than predicted (with a median increase of 2.8%) while those who did not watch any of the videos performed 1.8% better (median increase of 2.2%). Figure 1 presents this increase in academic performance. The lowest incoming GPA of any student was 1.93 (average incoming GPA was 3.09). The lines shown in Figure 1 are best-fit trendlines of the final grades for each group of students (those who used Video AI and those who did not) along with the grade scale (which is the standard grade scale across our institution). Figure 1 thus represents a strong data set since little manipulation of the data was undertaken and the data can thus be considered relatively raw.

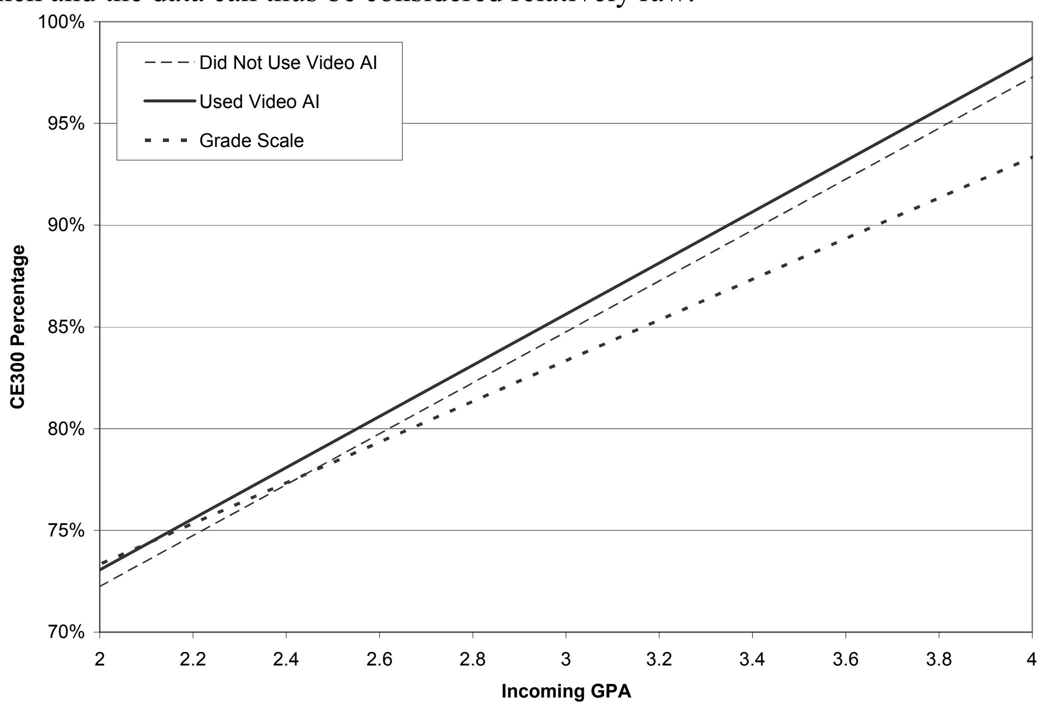

Figure 1 Academic Benefit of Video AI

We know that a student with a lower incoming GPA has potentially much more to gain. For example, a student with a 2.0 coming into our course should be expected to earn a 73% in the course (the predicted grade, *P*), while a student with a 3.0 could expect to earn 83%. The maximum potential increase in grade for the 2.0 student is thus 27% while the potential increase for the 3.0 student is only 17%. In order to account for this and verify that the aggregate academic gain was not being biased by these students with "more to gain", we calculated a normalized increase using the following (*N* is the normalized increase, *A* is actual course grade, and *P* is predicted grade based on incoming GPA):

$$N = \frac{A - P}{100\% - P}$$

Doing so resulted in the same conclusion: Those who made use of Video AI saw larger normalized increases. That is, students who watched videos as part of their study increased by a larger portion of their potential increase. Those who watched the videos increased on average 18.6% of their potential increase (17.1% median increase, standard deviation of 29.5%) while those who did not watch the videos saw an average normalized increase of 16.3% (median of 17.7%, standard deviation of 34.6%.) Interestingly, when compared to a very similar population of students from a previous semester in which there was no Video AI available, the normalized increase was nearly identical to the population that did not make use of videos (average: 16.1%, median: 16.3%, standard deviation: 32.3%).

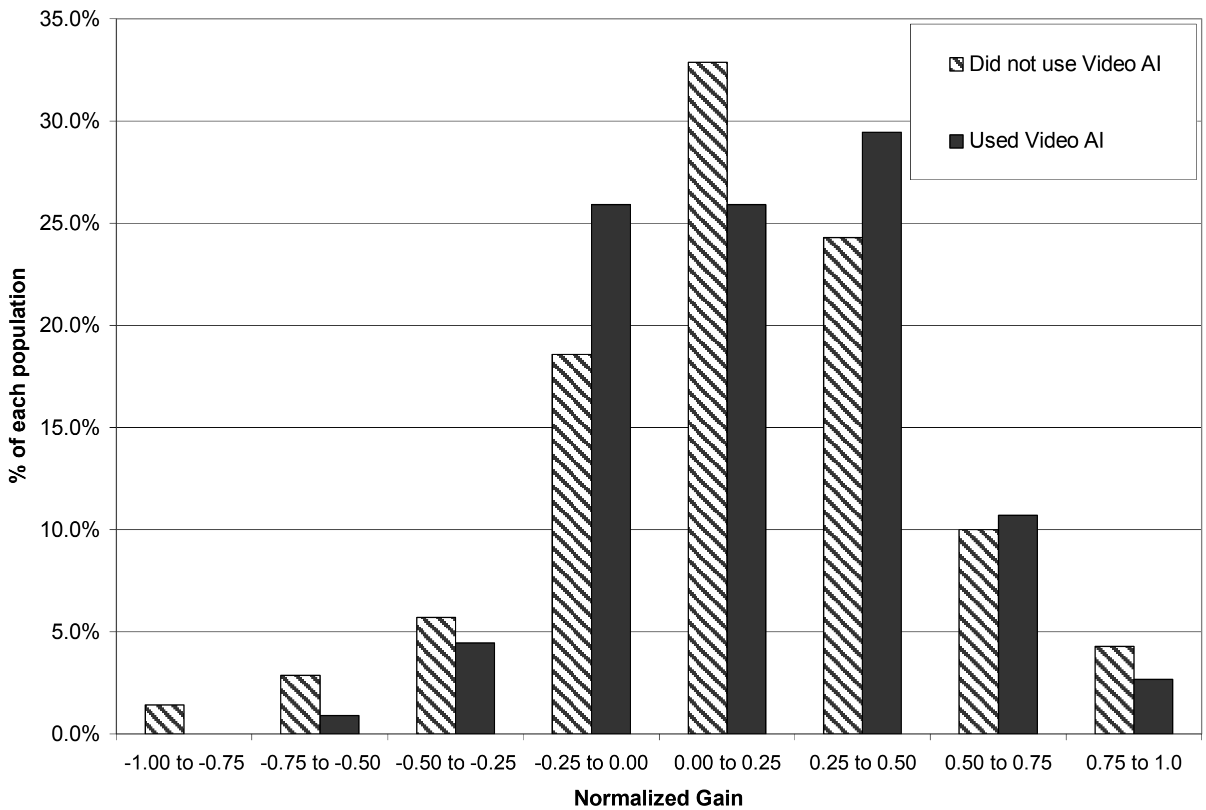

Figure 2 Normalized Gain by Population

An interesting finding was that Video AI is used by all levels of academic aptitude (as judged by the students' incoming GPA.) That is, students across the spectrum of previous academic performance make use of this resource, as seen in Figure 3. It is interesting to note that nearly all students who historically performed in the C-range watched these videos sometime during the course, but also nearly two-thirds of A-students also used Video AI. This demonstrates that students who typically struggle seem to appreciate having an additional resource available to them and, at the same time, those who typically perform well seem to still make use of multiple resources to maintain their academic record.

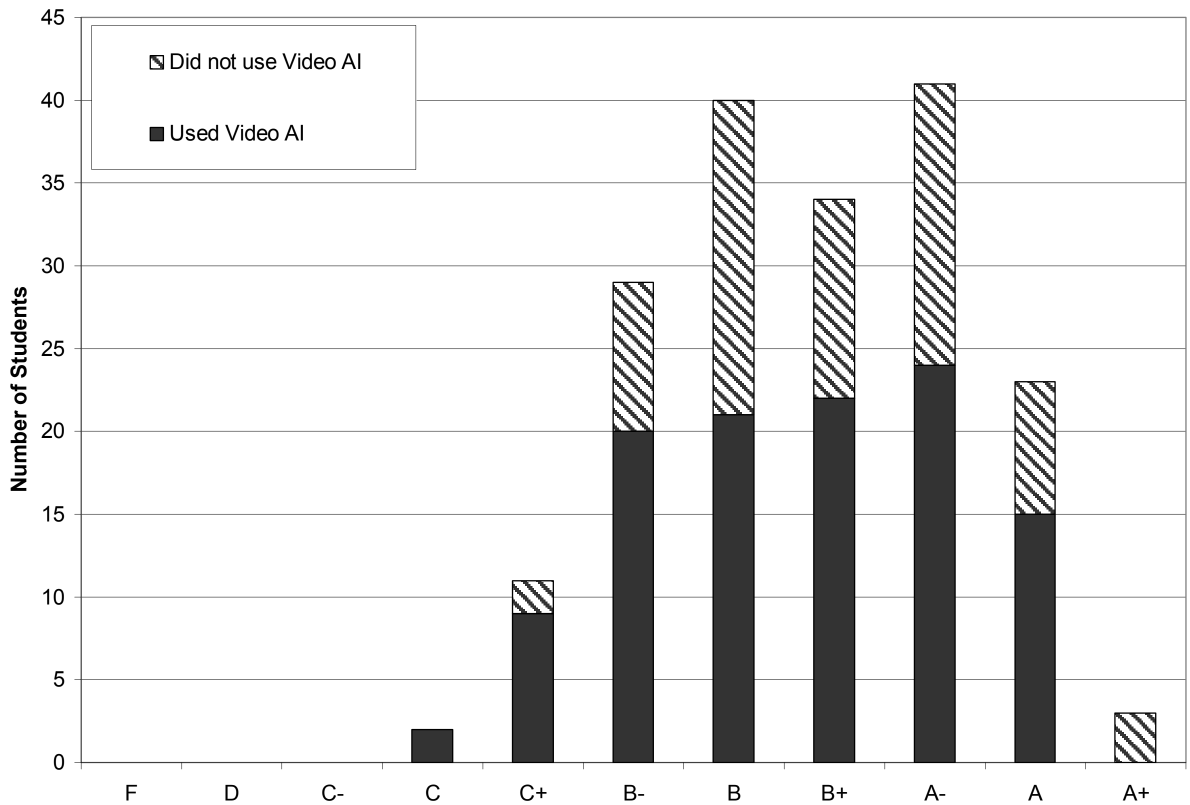

Figure 3 Usage of Video AI Based on Incoming GPA

Extended Results and Discussion

Since Video AI is a new idea within our department and institution, we administered a survey within the first two days of the semester to gain insight into perceived student preferences. The survey asked questions about whether or not they had used short videos to supplement learning in previous classes; if they had used videos before, what they thought about it; what type of video they would be most likely to use; and trends in podcast and RSS use.

We had an 85% response rate (156 of the 184 students enrolled in the course at the time). Interestingly, while only 28% had used videos to supplement their learning in a high school course, 50% of them reported using videos to supplement their learning in a college course. Nearly without exception, they stated that in previous courses they watched long videos (1-2 hours in length) to supplement learning in history and social science courses – many of these being documentaries or other movies. Many also reported watching videos for chemistry and physics courses to illustrate concepts or show demonstrations that were not done in class.

When asked about what length of video and type of content they would prefer, it is clear that students prefer to see examples being worked and the shorter the video the better (see Figure 4). This makes sense if you consider trends such as YouTube where the majority of the videos available are 5 – 10 minutes, or even shorter, and that students in math, science, and engineering courses tend to like seeing example problems that they can use as references when completing homework assignments. Interestingly, the idea of short videos discussing concepts was also favorably considered by the students. They were fairly evenly split on the desire to watch the recording of a 55-minute lesson with the vast majority stating they were not sure they would use it.

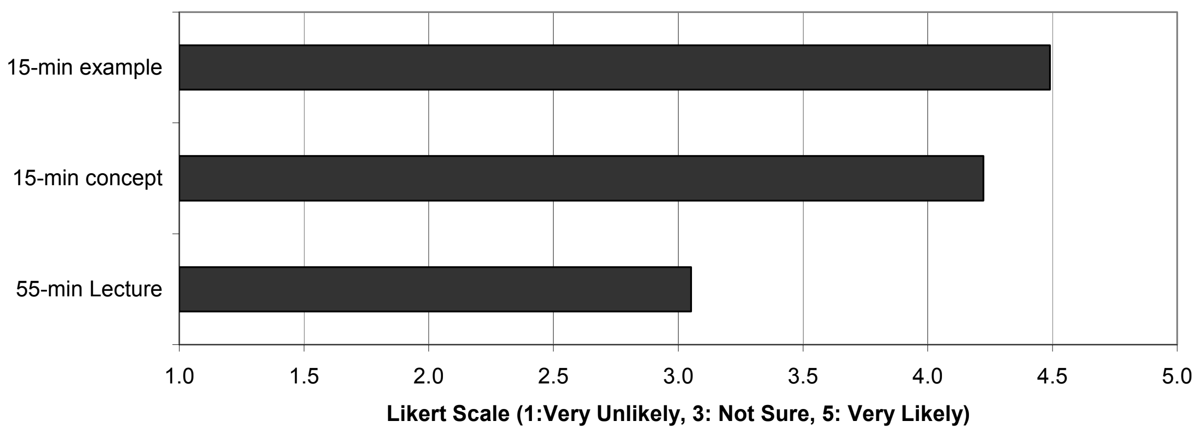

Figure 4 Student Usage Preferences for Video Length and Content

Prior to the start of the semester, we considered setting up an RSS feed to push new video content out to our students. Based on their feedback (only 9% use podcasts, and only 1% make use of RSS feeds) we chose not to implement this idea. We made content available in both Windows Media and iPod Video formats. While 38% of our students reported owning an iPod type of device that was capable of playing video, not one student ever used the iPod video format. Without exception, students watched the videos we created on their laptop computers.

Not surprisingly, students were most likely to watch the videos as they were completing assignments or preparing for exams. As shown in Figure 5, it is clear that usage peaked in the day or two prior to a major graded event. In the figure, "PS" = Problem Set; "WPR" = Written Progress Review (a mid-term exam); "TEE" = Term End Exam (the final exam). Due to a loss of data in the system, usage trends are unavailable prior to October 1.

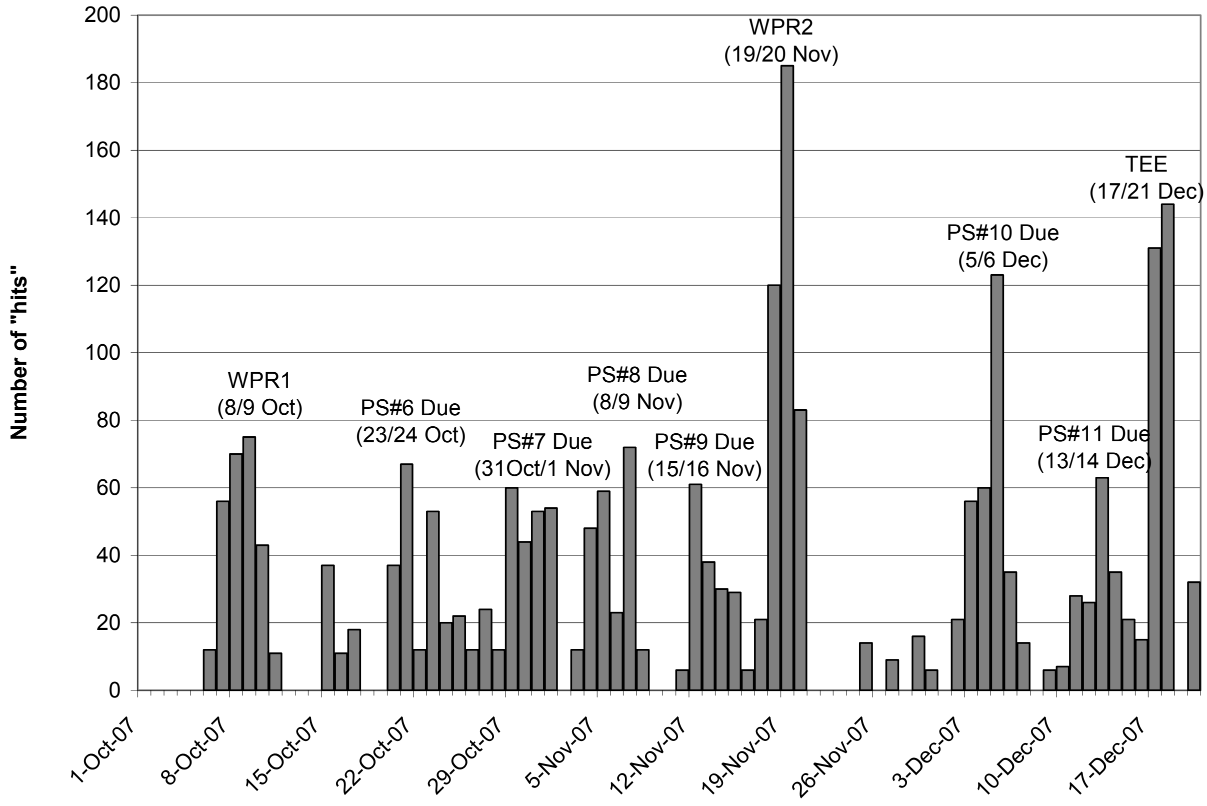

Figure 5 Video AI Usage by Date

As part of the course-end-feedback, we asked our students several questions about the use of Video AI within the context of our course. Numeric feedback corroborated the anecdotal feedback we had received during the semester – our students like the resource, watch the videos, and want to see similar videos available in other courses. Students who made use of Video AI reported using it somewhere between "sometime" and "frequently" both when completing homework assignments and when preparing for exams (see Figure 6). They reported the resource as "helpful" but not "essential" to their learning, and all but one student who used our videos sometime during the semester stated that they would like to see Video AI available in other courses (the one student who did not agree was "neutral" on the question.)

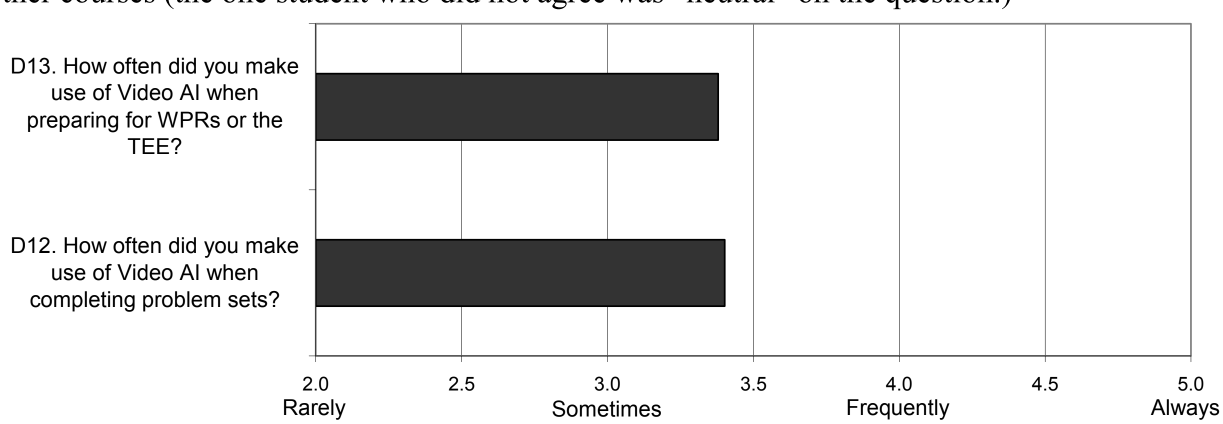

Figure 6 Reported Frequency of Use of Video AI

Knowing that there is often a mismatch "between common learning styles of engineering students and traditional teaching styles of engineering professors"[21] all of our students completed Felder's learning styles inventory, wrote about the impact of their learning preferences, and we noted which learning styles were more or less likely to make use of Video AI. We found that our students were predominately active/sensing/visual/sequential learners (see Figure 7) which is similar the "average" engineering student according to Felder.

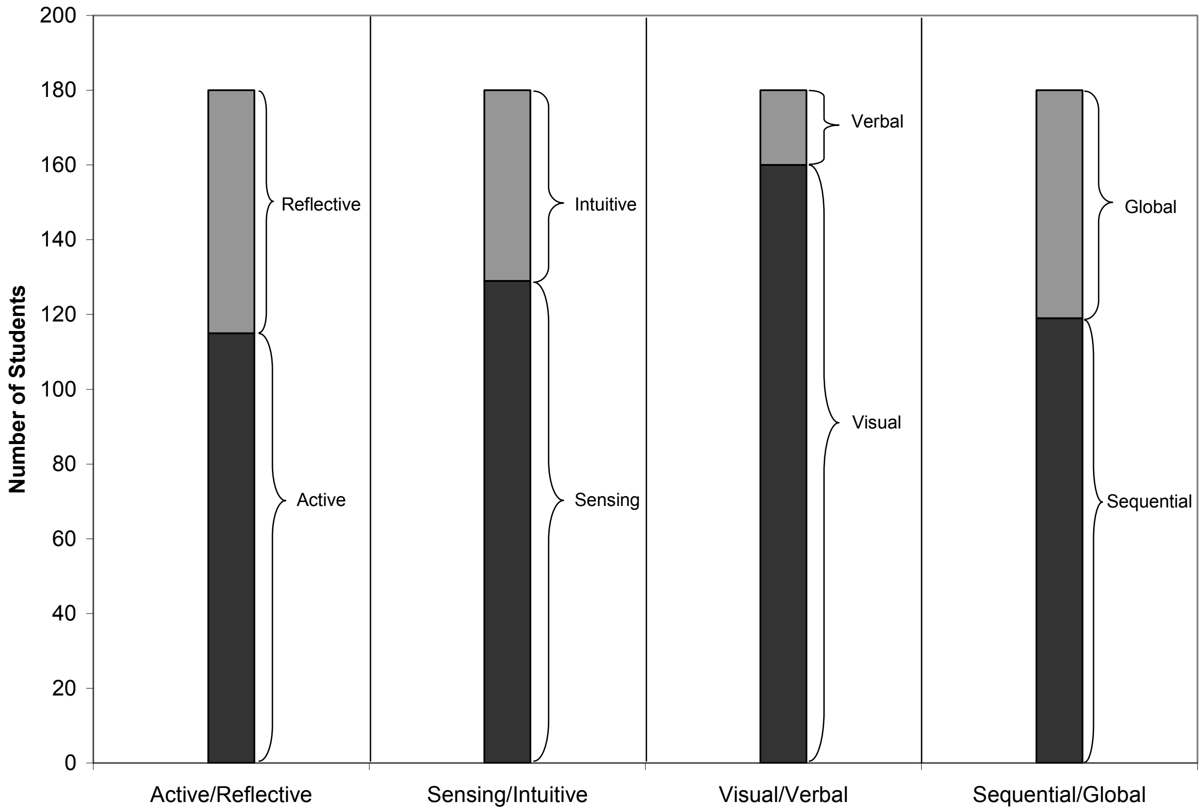

Figure 7 Distribution of Learning Styles

Since our videos are a blend of conceptual discussion and example problems, we hypothesized that these videos would appeal to both sensing and intuitive learners. We also hypothesized that visual learners would be more likely to use the resource than verbal learners, active more likely than reflective, and sequential more likely than global.

Interestingly, the videos were used equally across the learning styles (see Figure 8). We believe that this is the product of a number of factors. First, since we posted the videos early in the semester regardless of where in the context of the course they fit, the global learner was able to get a "sneak peek" of coming content and potentially put what was currently being discussed in the course into broader context. Surprisingly, usage statistics actually showed that a number of students accessed the video content prior to that video's topic being presented in class or covered by a graded event. Secondly, the majority of our students (57%) are balanced in two of the learning style categories (active/reflective and sequential/global). Finally, we believe the intuitive learners tend to be less comfortable in the course since we tend to emphasize problemsolving. Since intuitors are often impatient with details, perhaps they see Video AI as a way to help them overcome this and better master the material.

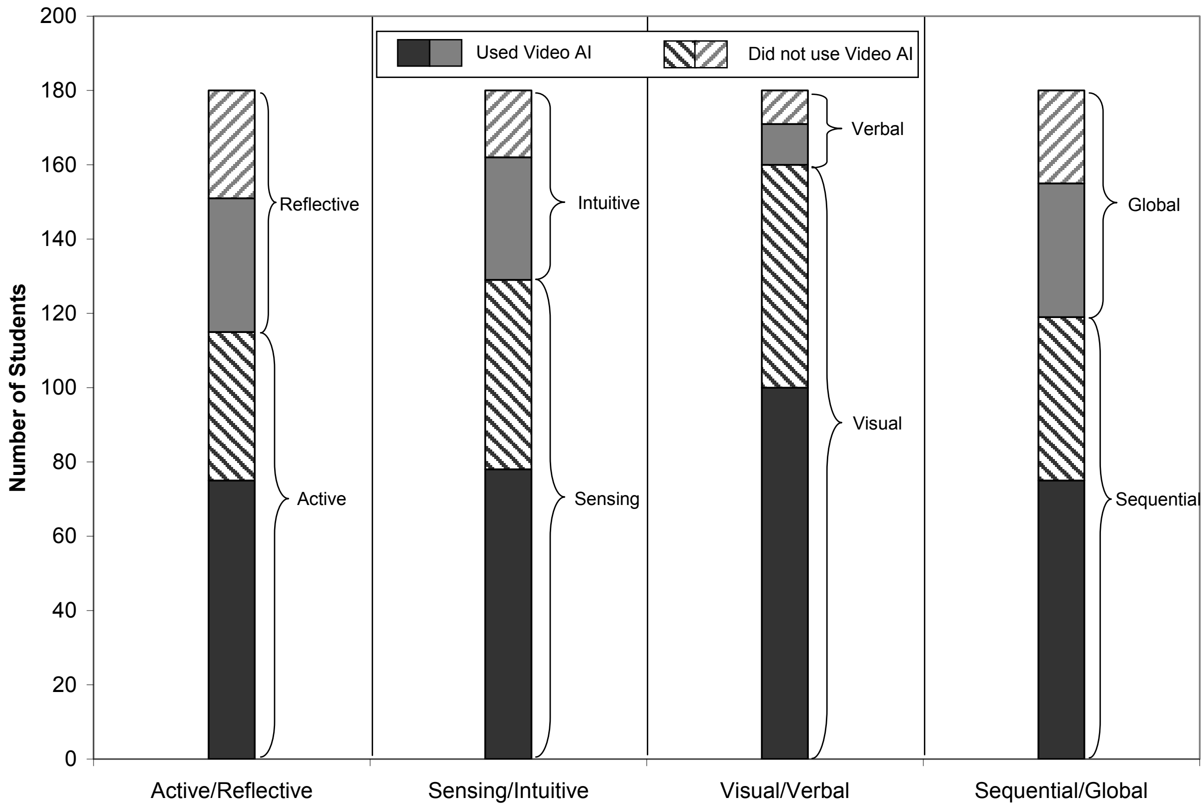

Figure 8 Learning Style Preferences Tied to Video AI Usage

We recognize that there are concerns among some engineering faculty about providing a resource such as these videos. One of these concerns is that providing videos of example problems will reduce student use of traditional resources (specifically, their textbooks and personal notes). We gathered data throughout the semester about the various resources used by students when completing homework assignments. Students checked the resources used on the cover sheet of their assignments. Participation ranged from 56% to 88% of students reporting resources used. It is interesting to note, when examining Figure 9, that use of the textbook and study guide problems (which were worked by the instructor in class) actually increased over the course of the semester. That is, they used these traditional resources more regularly as the semester went on. At the same time, use of Video AI increased over the first three assignments and then remained relatively stable for the remainder of the semester. Significantly, the videos saw less usage than any of the traditional methods on every assignment.

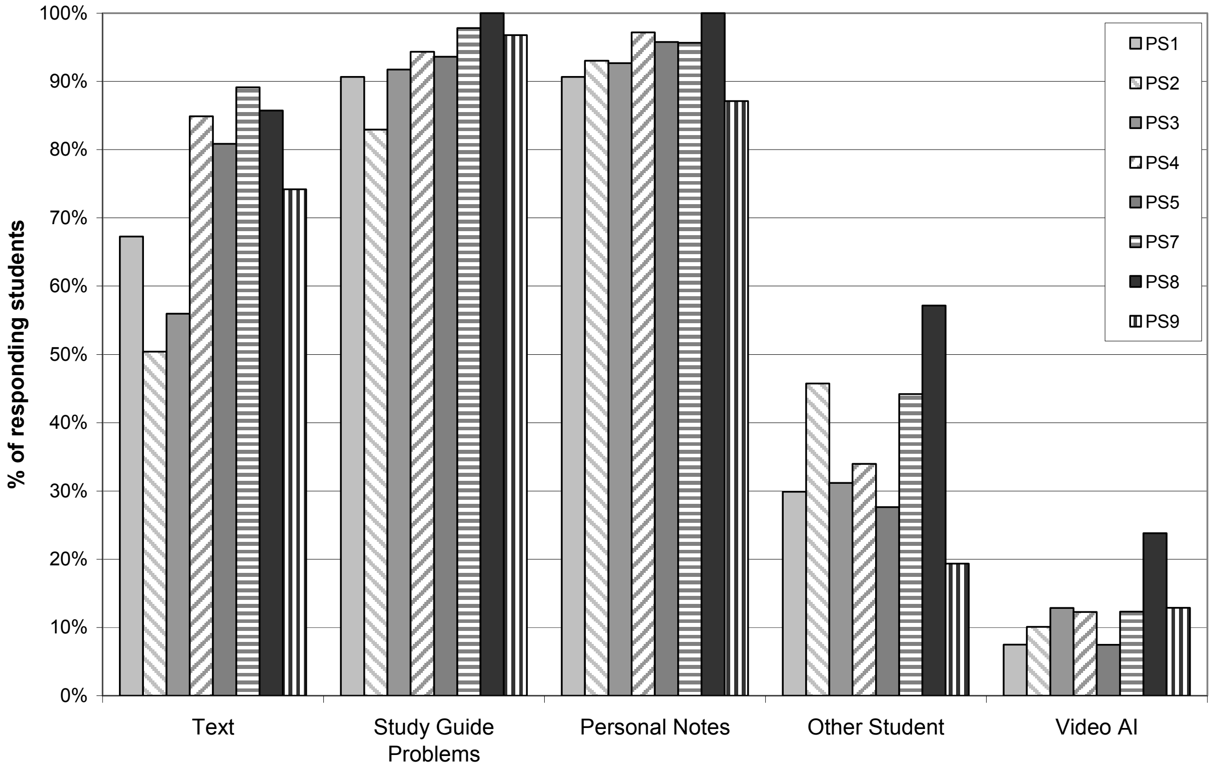

Figure 9 Resources Used When Completing Homework Assignments
(Note: "PS" is a "Problem Set". All assignments range in value from 40-60 points (out of 2000 in the course).)

Another concern is that providing videos will result in a reduction in class attendance and participation. At our institution, attendance is mandatory, so we can not speak directly to that concern, but we can offer some recommendations to limit the chance of skipping class and catching up by watching videos. If the videos are very focused, as ours are, it is very difficult to see the broader context that can be provided in a typical hour-long lesson. Also, videos do not exist for each and every topic covered in our course – they are offered for the topics that most commonly confound our students. So, in order to be presented with all of the course material, a student must attend class regularly. Concerning participation in class, our instructors noted absolutely no difference in participation in class between students who used Video AI and those who did not. In fact, it could likely be argued that those who watch the videos may be more likely to participate in class since they have had an "extra dose" of the material and may be more confident as a result. Future research on the impact of short, instructor-made videos on class attendance and participation would be very beneficial as educators continue to integrate advances in technology into their courses.

Implications and Thoughts for the Future

Meeting students on their own ground works, and the authors predict that on-demand learning of the type described here is only just the beginning. As bandwidth grows and the cost of connecting plummets, the ability of virtual environments to capture the interactions and reactions of real people increases. It is this, the presence of people, which makes things compelling. People are unpredictable, challenging, fun, annoying and without doubt, the most interesting thing there is. World of Warcraft, Second Life and other MMOGs (massive, multiplayer online games), where the principal things the actor encounters are representations of other users, are highly appealing, especially to those under 30, and presage a growth in such environments for more serious uses. It is thus possible to envision a virtual learning environment which is actually richer, more open and far less expensive than our current university model. Experiments like the one described here will certainly persist, but the likely big future winner will be an immersive learning environment where ready interaction with professors, fellow students, virtual objects and other embedded media will be rich, immediate and natural to the user.

Some educators may be concerned that the growth of on-demand digital environments will dehumanize learning, removing creativity, spontaneity and other intangibles from the intellectual growth of their students. Only time will tell, but the success of the MMOGs points to something quite different; people prefer to interact with real, live people; not simulated people, not stored images of people, but multi-capable, unconstrained and active persons who share the actor's goals. All of this implies a demand for increasingly varied virtual classrooms populated with knowledge, objects and a staggering array of simultaneous communication paths. These requirements in turn indicate a growth rather than diminishment of Lowman's necessary components for great teaching; interpersonal rapport and intellectual excitement[22]. As teachers, this means creating content and environments that the students want rather than need for survival, thus converting that offering from "push" to "pull" content. This revolutionary conversion represents an extraordinary challenge, but a challenge that must be met if we are to meet the students on their own ground.

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