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On Student Use and Perception of Video Tutorials in an Undergraduate Operations Research Course within an Engineering Curriculum

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Abstract

We consider student use and perception of video tutorials that were produced to serve as virtual office hours for an undergraduate Operations Research (OR) course. The video tutorials complemented the traditional classroom experience by offering different example applications, presentations of solution methods, and examples for different cases of an OR problem (e.g., maximize versus minimize objective). In order to understand student use and perception of these video tutorials, data was collected about the view counts of the videos and through a survey of the students. We analyze the effectiveness of the video tutorials as a learning aid by measuring student use, student perception of the tutorials with respect to their learning experience, and the perceived advantages of the video tutorials.

Keywords
Video Tutorials, Student Use, Student Perception, Hybrid Learning Environment

1. Introduction
This paper focuses on the role of video tutorials in an undergraduate Operations Research (OR) course in an Industrial Engineering (IE) curriculum. The video tutorials were produced to serve as somewhat of a 'virtual office hour' - they provided new examples and applications of the modeling and methodology presented during class lectures. This implementation of the video tutorials is distinct from recording lectures as was originally implemented by Gibbons et al. [1] and called tutored based video instruction (TVI). These voluntary video tutorials instead focus on smaller aspects of an overall lecture and were recorded by the teaching assistant for the course, thereby offering an alternative viewpoint in the explanation of the concepts. In addition, they often provided *complementary* examples to those done in class (for example, applying the simplex method to a 'maximize' or 'minimize' objective or presenting an algorithm via a different approach), enhancing the exposure of the students to course material. Lastly, our video tutorials tended to be more informal, focusing on the inner thought process associated with the steps taken to model and solve the problem.

The idea of using technology or video tutorials is not a new concept for OR (or, in general, engineering) courses. Stone [2] used the TVI concept applied to IE/OR curriculum and talked about the large attrition rates seen with strictly online courses. Seal and Przasnyski [3] utilize video tutorials for teaching OR and Management Science in a graduate-level, MBA course. Therefore, the target audience of our work is quite different from Seal and Przansnyski [3]. These video tutorials were highly scripted (even story-boarded), which is different from our video tutorials. For a specific problem, our video tutorials were more comprehensive typically taking it from mathematical modeling through implementation of an OR method. Further, Seal and Przansnski [3] only offer limited, high-level discussion on student feedback from video tutorials. Our work provides a rigorous analysis of student use and student perception of the video tutorials.

Researchers (see Gravett and Gill [4] and Meehan and Hyland [5]) have considered the use of video tutorials outside of the classroom to teach different needed college library skills, such as journal searching. Software skills are presented using required video tutorials by Troxell [6] and Hardin and Ellington [7] in a mathematical modeling course in order to expand the topics covered in class. Our use of video tutorials did not alter the traditional lectures presented, but instead were used to complement the covered material. Hardin and Ellington [7] proceed to assess their video tutorials by comparing scores on pre- and post-quizzes in addition to gathering a small number of student surveys. Our

assessment is different in that it focuses on student use and perception of *voluntary* video tutorials. Other tutorials are more interactive (see Leon et al. [8]) asking students to complete tasks during videos, but lacked components, such as audio.

A growing trend is the popularity of Massive Open Online Courses (MOOCs), such as Coursera. Daniel [9] and Herman [10] provide overviews of these types of courses. The use of our video tutorials provide the benefits seen from many MOOCs, such as their convenience and 'on-demand' nature, without taking away the benefits of a traditional classroom setting, thus providing a *hybrid* learning environment. We do note that others have used the term hybrid classroom or blended classroom to represent a different teaching environment. Tuckman [11] refers to a hybrid instructional model that consists of traditional lecture and interactive computer-based exercises. Mayadas et al. [12] provide an overview of online education and discuss hybrid "blended" classes featuring less face-to-face time with an instructor, which is inconsistent with our video tutorials. DeVaney [13] discusses the role of video tutorials for an online, graduate-level statistics course. Scherrer [14] considers a hybrid course with one meeting per week and videos featuring recorded audio played over powerpoint slides as the other class "meeting." The *hybrid* learning environment (or classroom) created as a result of the video tutorials is one in which an instructor still meets with the students and delivers a traditional classroom environment and then video tutorials are used to expand the experience by presenting new examples, more details, and new approaches for the material.

The contributions of this work is on analyzing the effectiveness of the video tutorials as measured through: (i) student use of the video tutorials, (ii) student perception of the tutorials with respect to their impact on the student's learning experience, and (iii) the perceived advantages of video tutorials integrated into the course. Data has been collected and analyzed on the temporal pattern of the 'views' of the various video tutorials. In addition, we conducted an end of the semester survey addressing how the students utilized and perceived the videos. The results indicate that our hybrid learning environment could be a powerful learning environment.

2. The OR Course Curriculum and the Integration of Video Tutorials

The course which the video tutorials were implemented, ISYE 4600: Operations Research Methods, is a four credit required course for Industrial and Management Engineering (IME) undergraduate students at Rensselear Polytechnic Institute (RPI). In the Fall 2012 semester, the undergraduate enrollment was 49 students. This course provides a comprehensive overview of both deterministic and stochastic OR concepts and methods. Table 1 provides a breakdown of the course by topics, the approximate number of weeks spent in each major topic, and the titles of their associated video tutorials, if one was produced. The video tutorials covered topics that were either requested by students or for areas where we believed and observed students struggling most with the material.

This course schedule is very dense and the video tutorials were able to present examples of particular methods, as class time was not always available to do multiple examples in class. The specific manners in which the videos enhanced the delivery of course material include:

- **Presentation of a Larger Number of 'Classic' Applications:** In the section of the course on linear programming models, resource allocation, personnel scheduling, and 'mixing' (e.g., chemicals) problems were presented during class. There was not enough time to cover other classic examples in class; however, a video tutorial was creating on modeling an application of the diet problem. This type of problem would not have been presented to the students without the use of video tutorials.
- **Alternative Presentation of an OR Method:** Certain solution methods, especially for network-based problems, can be presented in a number of different manners - the video tutorials allowed for a second manner to be presented for an OR Method. For example, a visual/graphical-based manner was utilized to present an algorithm to solve the shortest path problem. This manner split the nodes into two sets, one set contained nodes whose shortest path was found and the other set contained nodes whose shortest path was not found. The cut between these two sets (and the known shortest path lengths) were then utilized to determine the next node whose shortest path could be found. The video tutorial presented a similar shortest path method but focused more on an 'algorithmic' manner for its presentation. In particular, distance labels and predecessors were maintained for every node in the network and were updated when a distance label was set to be permanent.
- **Detailed Presentation of Different Cases of a Problem:** The video tutorials allowed for an active and detailed presentation of the different cases for a particular OR problem. For example, the class presentation of branch and bound for integer programs included an example with a 'maximize' objective. The associated video tutorial on branch and bound provided an example with a 'minimize' objective. Another example of this is in the

Course Topics	Video Number and Tutorial Topic
Linear Programming (4 weeks)	
Modeling and Applications	1. Planning Your Pet's Diet
The Simplex Method	2. Application of the Simplex Method
	3. Application of the Two-Phase Method for LPs
LP Software	4. Solving a Supermarket Sweep Problem
Duality and Sensitivity Analysis	
Network Optimization (2 weeks)	
Transportation Problem	
Shortest Path Problem	5. Meeting Under the Georgia Pine by Finding Shortest Paths
Minimum Spanning Tree Problem	
Maximum Flow Problem	
Integer Programming (2 weeks)	
Modeling and Applications	6. Locating Farmer's Markets
Branch and Bound Method	7. Applying Branch and Bound using Excel
Multi-Objective Optimization (1 week)	
Goal Programming	8. The Role of Weights in Modeling Classes of Goals
Efficient Frontier	9. Balancing Cost and Efficiency in Emergency Call Centers
Decision Analysis (1.5 weeks)	
Decision Rules	
Decision Trees	
Markov Chains (2 weeks)	
Steady-State Equations	10. Modeling and Solving for Steady-State Probabilities
Advanced Properties	
Markov Decision Processes	
Queueing Theory (2 weeks)	
Little's Law	
Birth and Death Processes	
$M/M/s$ Models	11. Utilization of Servers: An Application to I Love Lucy

Table 1: The OR course schedule and associated video tutorials

presentation of the goal programming section of the course. The application presented in class focused on an example where all goals were hoped to be met exactly (i.e., goals with '$=$' statements). The general formulation technique presented could be applied to goals with '$\leq$' and/or '$\geq$' statements by appropriately setting the penalties for deviating from the stated goal. The video tutorial produced for goal programming presented an example of how to set the penalties for the various types of goals and the deviations from them.

The video tutorials were created using the screen recording feature with microphone audio in QuickTime Player 10.1. This implementation method provided many benefits including that the software is free, easy to use, and had a relatively short learning curve to effectively implement the video tutorials. The process to produce a video included the following four steps: (i) decide on topic and problem, (ii) record video, (iii) upload video, and (iv) embed and post the video.

When a topic and problem were chosen for a video tutorial, there was limited preparatory work done. We believe that there is a benefit to seeing the example worked out in its entirety on the screen, including a discussion of the thought process of the person producing the video. Therefore, the main preparatory work performed included writing out the problem description, opening the appropriate files (text, pdf, and Excel), and adjusting the files zoom and font sizes to be large enough for easy viewing. During the production of the first couple video tutorials, a trial run was conducted but was not necessary for later tutorials. Once a video tutorial was completed, the file was uploaded to a Vimeo Plus account. The uploaded video was then embedded in HD onto the Teaching Assistant's website with a short description of the problem. Figure 1 shows a visual snapshot of one post which includes the video (with functionality to play, pause, and zoom to full screen) and the short description of the problem covered. A section with time break downs within the video was provided in this short description (e.g., Modeling is from Start - 5 minute mark, Applying the

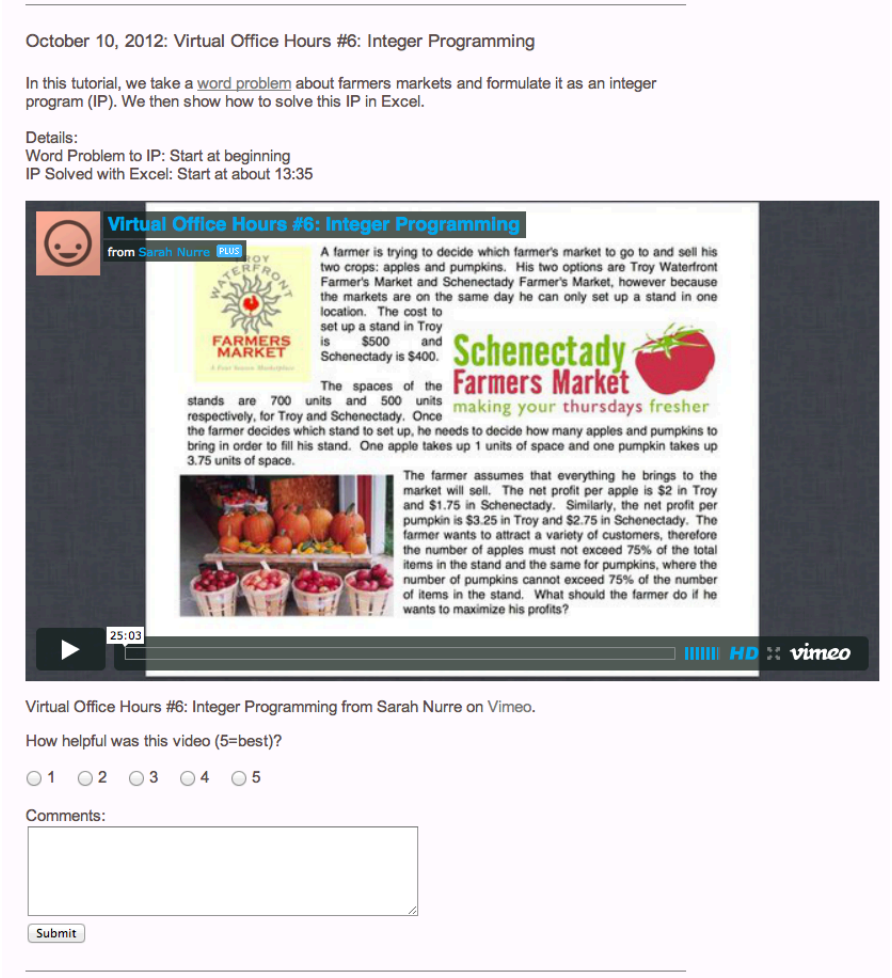

Figure 1: Visual snapshot of the web-based post for one specific video tutorial. Each post includes a short description of the problem covered by the video, a time navigation section, and the HD embedded video with controls to play, pause, and zoom to full screen.

Method is from the 5 minute mark - End). This enabled students to navigate to the appropriate time based on the portion of the problem providing the most challenge. Students were then informed of the newly posted video through the Announcement section of a WebCT-type platform. Further, note that the page containing the videos was embedded within the 'Links' section of this same platform.

3. Data Analysis and Results

This section focuses on the data and results that have been collected to help understand how students used these video tutorials. Two mechanisms were utilized to obtain this data: (i) the view counts (by day) of each of the video tutorials and (ii) a student survey at the end of the semester. The data collected through each of these mechanisms provides insight into how the students used the videos, when they viewed the videos, and how the videos were received by the students.

3.1 View Count Analysis

The number of video views by day were captured in order to gain insight into *if* and *when* the students were using the videos. This data is collected through the Vimeo Plus account and defines a view as either a partial or complete play of the video in one session. This means that if students played the video and paused or replayed it multiple times in

the same session, only one view was counted. We display these video view counts in Figures 2, 3, 4, and 5. Figure 2 displays the video view counts for those video tutorials pertaining to questions asked on Homework 1, which were also covered on the in-class Midterm. The horizontal axis displays the relevant days and the vertical axis displays the total number of view counts. In addition, the dates associated with the homework post date, due date, and return date as well as the Midterm date are included. Figures 3, 4, 5 follow the same format for Homework 2, Homework 3, and Homework 4, respectively. For Homeworks 3 and 4, the date of the Final is included in place of the Midterm.

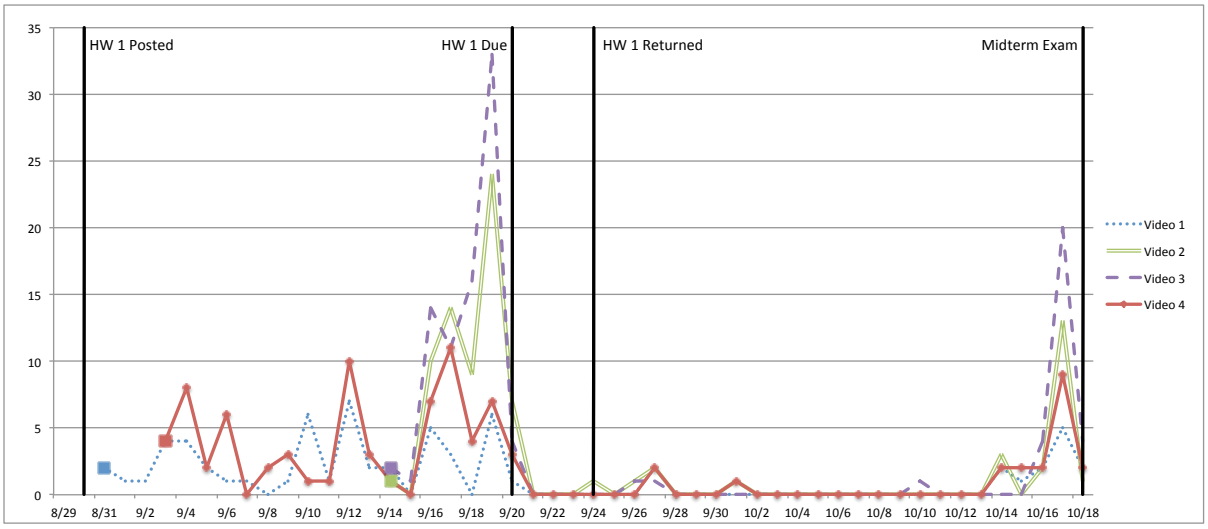

Figure 2: The number of video views by day for video tutorials pertaining to the first homework assignment. The vertical lines signify the date the assignment was posted, due, and returned. Topics covered in this homework assignment were also eligible for testing on the midterm exam, which is included as the farthest right vertical line.

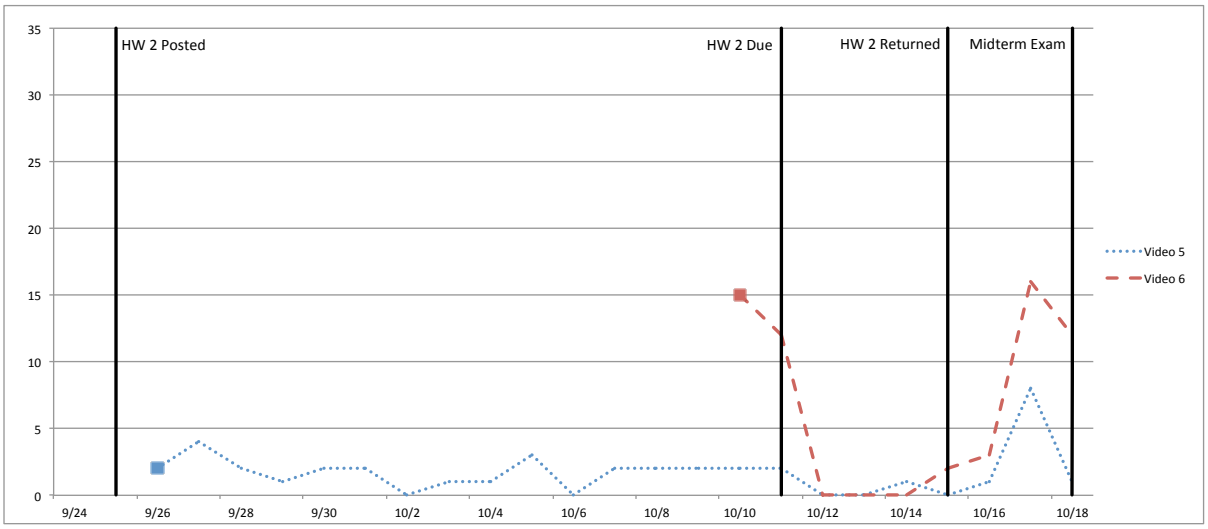

Figure 3: The number of video views by day for video tutorials pertaining to the second homework assignment

These figures indicate some clear trends of when the students are watching the videos. Spikes are apparent in all four figures immediately preceding the due date of the homeworks and the date of the relevant exam. One can also, potentially, infer the topics that provided the students with the most difficulty by looking at the magnitude of the spikes. For example, in Figure 2, Video 3, covering the two-phase simplex method, has the largest view count in the days leading up to the due date of Homework 1 and largest overall view count (see Table 2). From this, we can infer

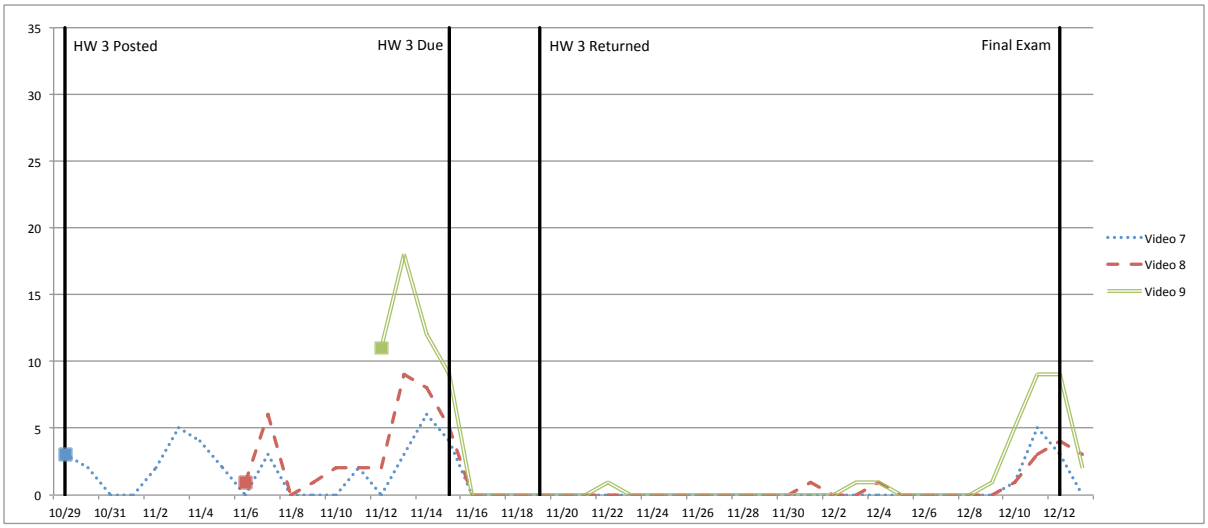

Figure 4: The number of video views by day for video tutorials pertaining to the third homework assignment. The topics covered here were eligible for testing on the final exam.

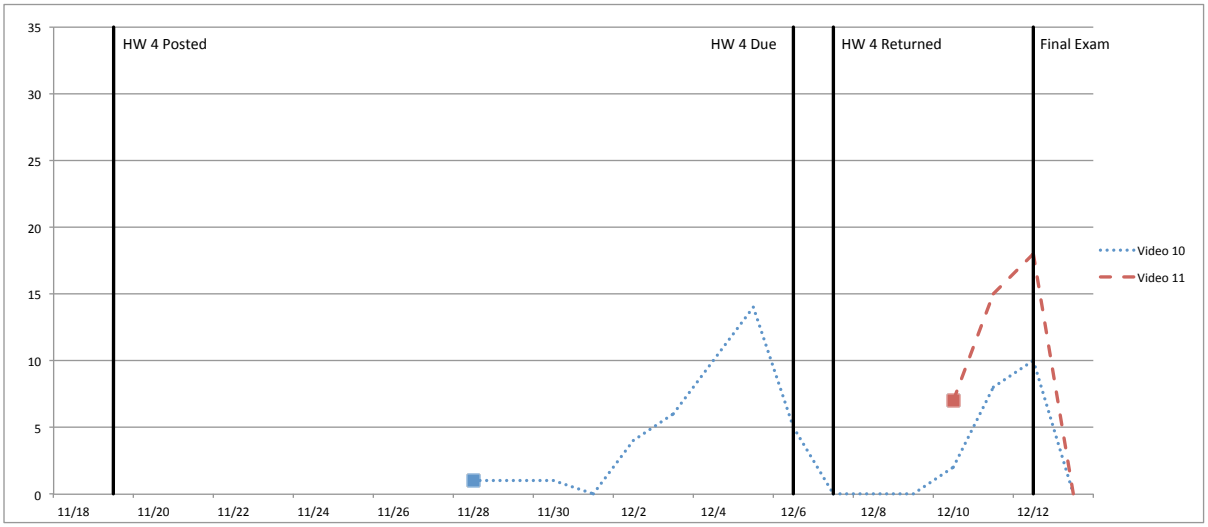

Figure 5: The number of video views by day for video tutorials pertaining to the fourth homework assignment

Video	1	2	3	4	5	6	7	8	9	10	11
Total Views	64	91	115	93	43	62	45	49	79	62	40

Table 2: The total view counts for each of the 11 video tutorials

that students were working on the homework problem associated with the two-phase simplex method up until its due date and students tended to need more help with it.

We now examine the total view counts for each video over the entire course of the semester in order to learn *if* the students utilized the videos. Table 2 provides a list of the eleven videos and their corresponding total view counts. The course had 49 enrolled students. From these view counts, we can decisively conclude that *yes*, the students did utilize the video tutorials over the duration of the course. For most videos, we see view counts higher than the total number of enrolled students. This means that many students watched a single video more than once. We surveyed the students to gather more information about why they viewed a video multiple times and their overall perception of the video tutorials, which we discuss in the next section.

3.2 Student Survey Results

In addition to examining view counts, a survey was conducted on the video tutorials. The overall course evaluation surveys at Rensselaer Polytechnic Institute are conducted online and are done anonymously. Instructors have the option of adding up to 10 course specific questions in the survey and we included several questions to gather information about the use and perception of the video tutorials. Further, class time was provided for students to complete this survey and all students enrolled in the class were notified through email about the course evaluation. Out of 49 enrolled students, 34 students completed the survey. The questions included in the survey could be broken down into three categories: student use, student perception of effectiveness, and student perception of the advantages of video tutorials. Note that an early semester survey was conducted with questions evaluating the traditional learning environment. Although there were no questions specifically about the video tutorials, 17 of the responses mentioned favorable review and advantages of the video tutorials just weeks into the course. We now discuss, in further detail, the results of the end of semester survey for questions from the three areas outlined.

The first question in the student use category focused on how many video tutorials (of the 11 produced) did the student watch. Only one student did not watch any of the video tutorials and over fifty percent of the respondents watched almost all of the videos (at least 8 of 11). Table 3 provides a breakdown of the responses.

Omit Response	None (0)	Some (3-7)	Almost All (8-10)	All (11)
4 (12%)	1 (3%)	10 (29%)	4 (12%)	15 (44%)

Table 3: Distribution, out of 34 students, for the number of video tutorials watched

The second question in the student use category was interested in determining if a student rewatched the video tutorials and the reasons for multiple plays of the same one. In particular, this open-ended question asked: *Did you watch any of the videos more than once? If so, why or for what purpose?*. Of the 31 students who responded to this question, 26 of them indicated that they watched the same video tutorial more than once during the course of the semester and 5 indicated they never watched a video tutorial more than once. There were two common reasons for watching the videos multiple times: (1) 14 of 26 (54%) discussed that they watched the video tutorial once as they were doing homework and then rewatch it in preparing for an exam and (2) 13 of 26 (50%) discussed that they replayed the video tutorial (or portions of it) to reinforce the steps of the method being discussed in the video in order to ensure their understanding of the method. Note that one student listed both (1) and (2) as their reasons which is why the total exceeds 26.

The second category of survey questions focused on the perceived effectiveness of the video tutorials in enhancing the student's understanding of the material. These questions were of the form that a statement was given and a student was asked to provide their level of agreement with that statement. The first question in this category focused on overall course material while the second focused specifically on the more difficult concepts presented in lecture. The students overwhelmingly perceived the tutorials as a significant contribution to their ability to learn the material. Table

4 provides the results associated with these questions.

Statement	Omit Response	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
The videos enhanced my knowledge of course material.	1 (3%)	0 (0%)	0 (0%)	1 (3%)	10 (30%)	22 (64%)
The videos clarified difficult concepts presented in lecture.	2 (6%)	0 (0%)	0 (0%)	1 (3%)	10 (18%)	22 (73%)

Table 4: Distribution (out of 34) of responses for questions on perceived effectiveness

Our last category of survey questions pertains to what the students perceived to be the advantages of the video tutorials. An open-ended question was first posed: *What did you like about the use of the video tutorials as a learning aid? Do you have any suggestions for their improvement.* Thirty students responded to this question, some listing multiple characteristics of the video tutorials which they liked. The two suggestions given for their future use were: (1) to better time the production of the video tutorial with the lecture on the same topic (for example, release the video tutorial the same day) and (2) build upon the current repository of video tutorials (keeping the current ones) so they cover more topics. The characteristics of the video tutorials which students listed as advantages include:

1. **Actively Demonstrating the Material (14 out of 30 responses):** Students often cited that the video tutorials provided an active, step-by-step discussion of applying an OR method to a problem. This active solving of a problem allowed students to see the material being applied again to a problem and, more importantly, let them pause the video to 'digest' the step that was just done. This leads to another listed advantage.
2. **On-Demand Nature and Ability to Control Pace of Video (15 out of 30 responses):** Students cited that the ability to have on-demand office hours for topics presented in video tutorials allowed them to learn at their selected pace and time. The ability to pause the video was extremely important since there was never a chance of a student getting lost in the material - they would simply rewind the video until they felt able to proceed onto the next section of the material.
3. **Bridging the Gap between Lecture and Homework (5 out of 30 responses):** Five students specifically stated that they enjoyed the fact that the video tutorials would move the material one step above the examples presented in class on an OR method. They viewed this as an advantage since it bridged the gap between the simpler examples from class and the harder problems from the homework. Several other students mentioned (in response to various questions) that the videos were helpful in trying to clarify questions on the material before they would attend office hours. This indirectly hints at the fact that the video tutorials were a good step in going from lecture to the homework.

The last question in the survey asked students to rate their agreement with the statement: *I would recommend the use of video tutorials in OR Methods in the future and other IME courses*. This statement moves towards whether the students felt strongly enough about the video tutorials to recommend them to others. The results (see Table 5) indicate that students highly recommend the use of video tutorials in the future. We further note that students mentioned the video tutorials in response to surveys in other courses. For example, the OR Methods course is traditionally taken during the same semester as another course in our curriculum. In the mid-semester survey for this other course, a number of responses suggested the use of video tutorials to help with the material in that course. This feedback reinforces the students' perception of the effectiveness of the video tutorials.

Omit Response	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1 (3%)	0 (0%)	0 (0%)	1 (3%)	8 (24%)	24 (70%)

Table 5: Distribution (out of 34) of Responses for Recommending the Future Use of Video Tutorials.

4. Discussion and Conclusions

In this section, we provide discussions on the realized benefits of our video tutorials, draw conclusions from our study, and present ideas for future work. Based on this investigation into the use of video tutorials integrated with a traditional classroom environment, we observed three main themes: (i) benefits from this hybrid learning environment,

(ii) benefits from a customized learning experience, and (iii) the high use and favorable perception from the students. There was also a benefit from the *production* of the video tutorials in that they allowed a graduate student to measure her own teaching effectiveness and think about her teaching style without the responsibility of being in charge of an entire course.

Our hybrid learning environment integrated traditional lectures (twice a week) and online video tutorials which went through more example problems, step by step, from model formulation to solution method. In contrast to previous use of video tutorials (for example, Seal and Przasnyski [3] or Hardin and Ellington [7]), our video tutorials were less scripted and, therefore, informal. From the students' perspective, this informal process was seen as beneficial because it shows the thought process associated with the steps of the example problems. From the instructor's and teaching assistant's perspective, the informal process was beneficial because it requires a small amount of extra time to create the supplemental online video tutorials.

This hybrid learning environment allowed more students to 'customize' their learning experience. Students with different backgrounds could utilize the video tutorials appropriately to strengthen the skills needed for the portions of the course proving to be the most difficult. They could watch the video tutorials on their schedule and use the video tutorials as a first step to traditional offices hours. This, further, meant that if the students had work or other commitments during traditional office hours, they still had an opportunity (through the video tutorials) for clarification of difficult concepts. The video tutorials helped students in the thought process of figuring out the example problems and answering many of their questions on the topic. If they still had remaining questions, traditional office hours were available as the next step in their understanding of the material. In the future, we plan to continue to increase the number of examples and topics covered in the video tutorials. It may then be interesting to produce multiple video tutorials on the *same topic* that are targeted to different learning styles, areas of interest, or future career plans.

Two main approaches were used to assess the student use and perception of the video tutorials: video view counts and student surveys. Based on the results of this assessment, we can conclude that the video tutorials were very well received. All but one student watched at least one video, with most students watching more than 80% of the videos. Many students watched the same video multiple times to better grasp the material and watched them both for completing homeworks and preparing for exams. The results were overwhelming optimistic, with students indicating a strong agreement that these video tutorials should be used in the future.

The purpose of this work was to analyze the perceived student use and effectiveness of our online video tutorials. With our view count analysis, we concluded that students did indeed use the video tutorials for the entirety of the course. We identified patterns in their use, by noticing high viewership directly before homework due dates and exam dates. Based on the results of student survey responses, we conclude that the perception is that the video tutorials are beneficial and enhance the students' learning experience. Lastly, we discussed many advantages of the video tutorials including active demonstration of the material, their convenience, and that they bridge the gap between lecture and homework.

We believe that our assessment of video tutorials through student use, student perception, and advantages provides a comprehensive analysis when measuring the 'student perception' dimension of an effective learning experience (see Kane [15]). This dimension links the student and teacher, within a triangle composed of student, teacher, and content. The other dimensions of effectiveness include student assessments (linking the student and content) and teacher assessment (linking the teacher and content). We plan to address these two dimensions in future work. For example, it may be of interest to determine how successful students are with the material before and after the release of a video tutorial on a particular subject.

5. Acknowledgements

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