EFFECTS OF VIDEO LECTURE ON STUDENTS' MASTERY OF ENGINEERING DESIGN SOFTWARE

by

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ABSTRACT

Video based tutorials can be found for nearly any topic piquing one's interest. This study analyzes the effects of video-based instruction by comparing it to live lecture instruction in a high school introduction to engineering course. The study measured students' rate of mastery of basic modeling skills in Autodesk Inventor, a three-dimensional design software. Using Likert surveys and student interviews, students' disposition toward learning the software and personal preference for type of instruction were also recorded. The results indicated that video lecture instruction increased students' rate of mastery and retention of basic modeling skills and was students' preferred method of instruction for new material.

INTRODUCTION AND BACKGROUND

I currently teach at Glacier High School in Kalispell, Montana. The school has approximately 1,350 students and is one of two high schools in Kalispell. Twenty seven percent of students qualify for free and reduced lunch (OPI, 2016-17). The average household income is one and a half percent above the state average (Turner, Fuchs, & Todman, 2015). Glacier High School's demographics closely resemble that of the demographics of Kalispell. Kalispell is 94.2% Caucasian, 2.9% Latino, 1% Native American, and 1% Asian (Bureau, 2016). The high school is on a 50-minute class schedule with seven periods a day. I have chosen to implement my classroom research project in the three sections of Introduction to Engineering Design (IED) courses I teach at Glacier High School.

Glacier High School participates in the Project Lead the Way engineering curriculum by offering six of its engineering courses. IED is the foundational course in which students apply the basics of the engineering design process primarily through project-based learning. Students are introduced to the three-dimensional design software Autodesk Inventor where they learn to create models of conceptual designs and document these designs according to acceptable engineering practices. Autodesk Inventor is a robust program that can be challenging for students to master. In the past, I have used a combination of paper-based tutorials, live lecture, and video tutorials to help students learn how to use the program. Inevitably, when instructing students using a live lecture method, one or two students will slow the pace of instruction because of an unforeseen difficulty with their individual computer or a misunderstanding of the presentation. During these lectures, the majority of the class is left waiting for the next step as one or

two students try to catch up or receive direct assistance from me. Recognizing the inefficiencies of this process, I began seeking different methods of instruction for the acquisition of software skills. Both paper-based and video lecture tutorials allowed students to go at their own pace and ask questions as needed. These two methods seemed superior to the live instructional method and I started implementing more video lecture tutorials. Relying almost completely on anecdotal evidence, I began thinking video lecture was indeed increasing student achievement. This study is designed to determine the validity of my preconceived notion that video lecture leads to increased learning.

My opinion may have been formed by the technological advancements that permeate students' personal lives. Most of my students have cell phones that allow them to access digital information instantly. Students are very accustomed to communicating digitally for social and academic reasons. Over the past five years in education, I have found a greater percentage of students willing to spend hours searching for tutorial videos to explain a concept they don't understand when twenty minutes of textbook reading would have led to an accurate understanding of the material. Additionally, video instruction has never been easier to create and make accessible to students. Instructional practices such as the flipped classroom model are becoming more common. Online tutoring websites such as Khan Academy continue to gain popularity and YouTube instructional videos get millions of views each day. Despite the growing trend of video-based instruction, the volume of research on the topic is quite limited and inconclusive.

The purpose of this study is to investigate the effects of video lecture instruction on the rate of mastery of Autodesk Inventor and student dispositions in IED. My interest

in video lecture in my classroom this year led to the creation of my focus statement: What are the effects of video lecture instruction when compared to traditional instruction on students' rate of mastering three-dimensional computer-aided design software?

1. Does video lecture instruction increase student engagement in learning when compared to traditional lecture methods?
2. Does video lecture instruction decrease the frequency of student-to-teacher questions regarding the software?

CONCEPTUAL FRAMEWORK

Since the technological revolution, advances in technology have greatly influenced the art and science of teaching. Technology is now used more frequently in the educational setting than it ever has been in years past. Educators and students alike have instant access to information accessible through a variety of medium. Most notably, the use of teacher created videos as an educational tool has increased in popularity in the last decade. Interactive simulations and video sharing have provided access to content that would otherwise be inaccessible in the classroom. Students have instant access to hundreds of video tutorials outside of class, a popular example being Khan Academy. The flipped classroom instructional model has become a common instructional strategy, requiring students to watch video lectures at home and work problems in class with their peers. Prominent universities are recording lectures and creating massive open online courses for free. Many universities offer distance education courses allowing students to receive credits from a university without having to step foot on their campus. In 2014 alone, one in four post baccalaureate students were enrolled in exclusively distance

education courses and almost thirty percent of students in higher education had taken at least one distance education course (Dillow, 2016). These courses primarily rely on video lecture to deliver course content to students through prerecorded videos or simulcasting. In a 2016 survey of students and educators across the globe, 87% of respondents agreed that online learning will grow in importance and acceptance with 86% also stating their organization has teachers currently using video in the classroom (Kaltura, 2016). Despite being used extensively in the educational setting, research does not agree on the effectiveness of video as a method of content delivery.

Video instruction has been shown to positively impact student experience in many cases. In a university in Australia, an undergraduate engineering course teaching computer programming through traditional lecture participated in a three-year research study to analyze the effects of video-based lecture. The traditional lecture was replaced with video lecture and data was collected on student achievement and student perception of the class. The study found that video tutorials, when specifically designed to address information students would be assessed on, increased student engagement in the course and reduced the failure rate of the course from 30% to 13%. On student surveys, students reported higher satisfaction with the course and the instructor when compared to the traditional lecture (Wells, Barry, & Spence, 2012). The researchers attributed most of the beneficial effects of video tutorials to their ability to provide instruction that is both flexible to student schedules and provide education on-demand. The conceptual difficulty of the material being covered in a course does not seem to impact the effectiveness of video tutorials. Lloyd and Robertson (2012) demonstrated that screencast tutorials, a type

of video tutorial that records an instructor's screen, "are an effective and efficient tool for enhancing student learning, especially for higher order conceptual statistical knowledge compared to traditional instructional techniques" (p. 67). In a separate study of undergraduate analytical chemistry courses, video tutorials that were specifically created to address the most challenging chemistry concepts increased student understanding of the material and received overwhelming positive student feedback on surveys. These tutorial videos were designed to be short and to the point (Yi, Swenson, & Lents, 2012).

In addition to complex conceptual learning, video tutorials have been used to teach procedural knowledge in software programs. In a study comparing paper-based tutorials to video tutorials for learning formatting in Microsoft Word, van der Meij and van der Meij (2014) determined video tutorials produced a higher task completion rate and outperformed the paper-based tutorials. Palmiter and Elkerton (1993) found users learned software much more quickly when viewing a video demonstration compared to text based learning. However, the video users demonstrated lower retention and poor knowledge transfer when compared to the text-based users. The difference in initial performance and long-term learning was attributed to video learning creating a perception of learning as users simply mimic the tasks in the video. In contradiction, van der Meij and van der Meij (2014) conducted a follow-up study on learning retention with video based tutorials in Microsoft Word finding student learning was not only stable but video tutorial students outperformed paper-based tutorial students in a retention test given a week later. The positive results of video tutorials are further supported by a meta-analysis study of 26 primary research studies comparing static graphic visualizations to

animated instructional material. Berney and Bétrancourt (2016) concluded animation provided significantly higher learning for procedural-motor knowledge tasks and animation with auditory commentary proved to be the most effective method.

While video tutorials have been shown to improve learning of procedural software programs, the positive effect of video tutorials is not consistent in all studies. In a usability study of the library search database ERIC, undergraduate and graduate students compared a static web-page tutorial to a screencast tutorial. In all cases, students who used the static web-page tutorial outperformed students using the screencast tutorial (Mestre, 2012). Students reported the static tutorial allowed for quicker information retrieval by scrolling through a page as opposed to searching through a video. The screencast tutorial required students to remember everything presented because it was transient information. If they needed to find the information again, they would have to search for the exact time in the video pertaining to their question. Turner, Fuchs, and Todman (2015) provided further justification of the superiority of text-based instruction for learning database-searching tasks. Participants in their study were asked to learn a database-searching task by viewing a screencast or using a test-and-image tutorial. In all iterations of the study, text-and-image based tutorials were more effective. In another study by Varao-Sousa and Kingstone (2015) live lecture was compared to video lecture in an introductory college psychology course. The study showed students' memory performance was higher for the live lecture. In addition, students reported higher interest ratings and higher motivation for live instructor lectures when compared to video lecture. A similar study was conducted in the clinical section of a third-year periodontology

course where live lecture instruction was compared to video lecture. Students experiencing the live lecture earned significantly higher scores on the post-test than those of the video lecture (Ramlogan, Raman, & Sweet, 2014). Clearly there is no consensus in research stating the effects of video lecture in all instructional environments. Video lecture has proven to be successful for some learning outcomes yet deficient when compared to live lecture or static tutorials for other learning outcomes.

Despite the fact research does not agree on when or how to implement effective video lecture, research does offer a great deal of information on how to create effective video lectures. Ozan and Ozarslan (2016) collected data to examine the behaviors of students accessing video lecture content. They found learners who watched online videos in their entirety scored higher on exams. Additionally, videos that were shorter in length, watched in full screen mode, employed an interview-style presentation, or had a female lecturer as opposed to male were more likely to be watched completely by learners. van der Meij and van der Meij (2013) compiled a list of instructional video guidelines that also suggested short videos with female narration. They also stated an effective instructional video has a carefully crafted title, allows users to adjust playback features such as speed, provides a task preview before instructing, and focuses on procedural knowledge rather than conceptual information. User playback options were further supported by a study comparing instructional videos for knot tying. Interactive videos, allowing users to adjust playback such as pausing or slowing down, were compared to identical non-interactive videos. Student performance was measured by timing how long it took students to master several types of knots, revealing students watching the

interactive videos spent substantially less time mastering the knots than those watching non-interactive videos (Schwan & Riempp, 2004).

In two studies with over thirty faculty and seven hundred students, Danielson, Preast, Bender, and Hassall (2014) found that the pace of the course can impact the effectiveness of video instruction stating students are more likely to view video instruction in courses that "move quickly, rely heavily on lecture, were perceived as highly relevant to their future success, and contained information not available in other formats" (p. 121). Moreover, courses that taught science from a research teaching context were more likely to have students watching video lecture when compared to teaching from an applied science context. Even the size of the instructor's image in a picture-in-picture video lecture can impact learning. Pi, Hong, and Yang (2017) found that video lecture with a small or medium sized instructor's image attributed to greater student learning satisfaction. In a separate study, students watching videos with human pointing cues outperformed students watching videos with non-human visual cues (Zhongling, Jianzhong, & Jiumin, 2017).

Chen and Wu (2015) compared the effects of different types of video lecture on student learning. Each student in the study watched lecture capture (video recording of live lecture), voice over presentation (slides with audio of instructor), and picture-in-picture. The study concluded the lecture capture and picture-in-picture methods were significantly better at increasing student performance than voice over presentation. A secondary research question compared the learning styles of students to the effectiveness

of each type of video lecture finding differences in learning style did not impact learning performance when comparing video to video.

While research may not agree on the effectiveness of video instruction in all learning environments, video instruction has clearly been shown to benefit learning in certain environments when carefully planned and properly implemented. The characteristics for effective instructional video creation have been well documented by research and should be used as general guidelines.

METHODOLOGY

The purpose of this study was to compare the effects of video lecture instruction to traditional live lecture instruction on students' rate of mastering three-dimensional computer-aided design (CAD) software. Three sections of IED participated in the study. The majority (78%) of students were ninth graders, 11% tenth graders, and 11% juniors and seniors (N=65). Of the students in class, 83% were male. Five students had accommodations. Every section met after lunch in a classroom with a one-to-one student-to-computer ratio. The research methodology for this project received an exemption by Montana State University's Institutional Review Board and compliance for working with human subjects was maintained (Appendix A).

Treatment for this study began during the first unit students accessed the CAD software. All students completed the Student Interview Questions before and after the unit was started (Appendix B). All sections of IED completed the first introductory activity, Software Modeling Introduction, which included five short videos by the CAD software company teaching students how to navigate the software panels, create files and save correctly, locate features in a part file, and manipulate the view of a part (Appendix

C). The first activity provided opportunity for students to get familiar with the program and acted as a baseline of knowledge for all three classes. No modeling skills were taught in this first activity.

After the introduction activity, students in sections two and three of the course were assigned to the treatment group while section one remained as a traditional lecture (N_t=41). For the study, the primary learning outcome for all three sections was to master additive and subtractive modeling in the CAD software for basic shapes. Instruction for the treatment group was delivered exclusively by two instructional video lectures pre-recorded by the instructor. The first video lecture provided step-by-step instruction on how to model Video Object 1 using additive methods and then again using subtractive methods (Appendix D). The second video provided step-by-step instruction on how to model Video Object 2 using additive and subtractive methods (Appendix E). Upon entering class, the treatment group was given a hard copy of both Video Object 1 and Video Object 2 and directed to access the video lectures online to complete the activity. Following the video lectures, students were required to model each part twice, once with additive and once with subtractive methods, creating a total of four files. The instructor circled through the room during this time monitoring student progress and answering student questions as they arose. Three class periods were devoted to this instructional time. The number of student-to-teacher questions was recorded for each class period. Students were directed to raise their hand when they had completed each model and the instructor checked for completeness and accuracy. If the model was complete and accurate, the instructor recorded the total amount of time the student took to complete the

activity. Every fifteen minutes during each class period, the instructor would document the number of students on task. On task was defined as a student either watching the tutorial video or diligently working in the software program to complete the models.

Section one was assigned as the non-treatment group (N_{nt}=21). Upon entering class, the non-treatment group was given a hard copy of both Video Object 1 and Video Object 2 and the instructor provided a 15-minute live lecture demonstrating how to model Video Object 1 and Video Object 2 with both additive and subtractive methods. The instructor's screen was broadcast to each student's computer screen so they could clearly see each key stroke and mouse click as the models were made. Students were encouraged to ask questions and engage during the live lecture. Aside from student questions, material was presented in the identical order and detail as in the video instruction for the treatment groups. There was no time given between demonstrations of Video Object 1 and Video Object 2 for students to begin modeling. After the live lecture demonstration, students were instructed to create four models just as they were in the treatment. The instructor circled through the classroom answering and recording the number of questions just as he had in the treatment group. Every fifteen minutes the instructor would note the number of students on task. On task was defined as working in the software program to complete the models. As students finished, models were checked for accuracy and the time required to complete the models was recorded for each student.

After all sections had completed the models of the objects, they were instructed to complete the Model Creation Activity (Appendix F). The instructor circled the room answering questions and again recorded the number of students on task every 15 minutes.

Students were free to ask each other questions during this time. When students had completed all four of the models in the activity, the instructor checked the models for accuracy and then recorded the total time each student took to complete the activity.

On the fifth class day, all three sections of IED were given the 3D Modeling Test (Appendix G). The test asked students to model one part using any method they prefer. Internet access on all computers was blocked during the test and students were not allowed to talk with neighbors. Where possible, students were separated by one computer for testing. When students were finished with their model, they were instructed to raise their hand and have the instructor check the model for accuracy and completeness. If accurate and complete the instructor would record the total time the student spent on modeling. The student would then answer the rest of the questions on the 3D Modeling Test. The instructor did not provide any additional assistance on the test. After completing the 3D Modeling Test, students took the Post Treatment Likert Survey and answered the Student Interview Questions (Appendix H).

Time required for students to accurately complete each modeling activity was the primary method for determining the level of mastery of the CAD software. The times required for the treatment and non-treatment groups to complete Video Object 1, Video Object 2, and the Model Creation Activity were compared statistically. To determine if there was a statistical difference between the treatment and non-treatment groups, the time values for all models were analyzed using a Wilcoxon Rank Sum Test. In the summative 3D Modeling Test, the time required for students to complete the model was

also analyzed statistically and statistical significance was tested using the Wilcoxon Rank Sum Test.

Responses to the Post Treatment Likert Survey were used to quantify students' attitudes toward the CAD software, preference toward video lectures, and self-perceived competency in the CAD software. Responses were interpreted graphically in a diverging stacked bar chart. Students responded with Strongly Agree, Agree, Disagree, or Strongly Disagree. The Likert data was tallied quantitatively. The pre and post Likert items were individually analyzed for statistically significant changes using the Fisher's Exact Test. Responses were removed from the data if students responded the same to every question in the survey or if they did not complete all activities.

Student Interview Questions were used to qualitatively assess students' learning preference, confidence in the CAD software, and comments about the instructional videos. All students were asked to participate in the survey. Pre and post student responses to the Student Interview Questions were analyzed graphically and using a Fisher's Exact Test.

A Chi-squared test of independence was used to determine if on task time was independent of the type of instruction. Percent of students on task for the treatment group was also compared to time on task for the non-treatment group using Fisher's Exact Test. All data collection instruments are summarized in the triangulation matrix (Table 1).

Table 1
Data Triangulation Matrix

Data Collection Source	Primary Question: What are the effects of video lecture instruction when compared to traditional instruction on students' rate of mastering three-dimensional computer-aided design software?	Secondary Question: Does video lecture instruction increase student engagement in learning when compared to traditional lecture methods?	Secondary Question: Does video lecture instruction decrease the frequency of student questions regarding software commands?
Model Creation Activity	x		
3D Modeling Test	x		
Pre- and Post-Student Interview Questions	x	x	
Post Treatment Likert Survey	x	x	x
Frequency of Student-Teacher Questions	x		x
Teacher Observation of Time on Task		x	x

DATA AND ANALYSIS

The results of the pre-treatment Student Interview Survey indicated that 76% of students would summarize their prior experience in Autodesk Inventor as no to very little experience (N=55). When asked if they could model parts in the three-dimensional design software, 85% of students indicated they could not model any part or only model parts with very basic shapes. One student stated, "The program previously mentioned I have yet to try. It would be nice if going into it the program is explained as if no one has ever used the program, and all the basics get covered." To determine students' confidence in the software before the treatment, they were asked to rank their confidence on a scale

from 1 to 5 with 5 being the most confident. Fifty-six percent of students chose a confidence of 1 or 2. None of the students ranked their confidence at a 5, and 15% ranked their confidence at a 4 (Figure 1). According to a Chi-Squared test for independence, student responses ranking their confidence were independent of the group, treatment or non-treatment ($p=1$, $df=1$). In other words, the pre-survey results indicated students in the treatment and non-treatment groups had similar experience and confidence in the software package prior to this unit, establishing a baseline for this classroom research project. Students' confidence with Autodesk Inventor significantly increased after the unit with 76% of students choosing a 4 or 5 on the confidence scale compared to only 15% before the unit. A Fisher's Exact test comparing the pre-treatment to post-treatment distributions yielded a p-value of 1.8×10^{-13}. There was no significant difference in the distribution of student responses when comparing the live lecture group to the video lecture group on the post unit survey ($p=0.89$).

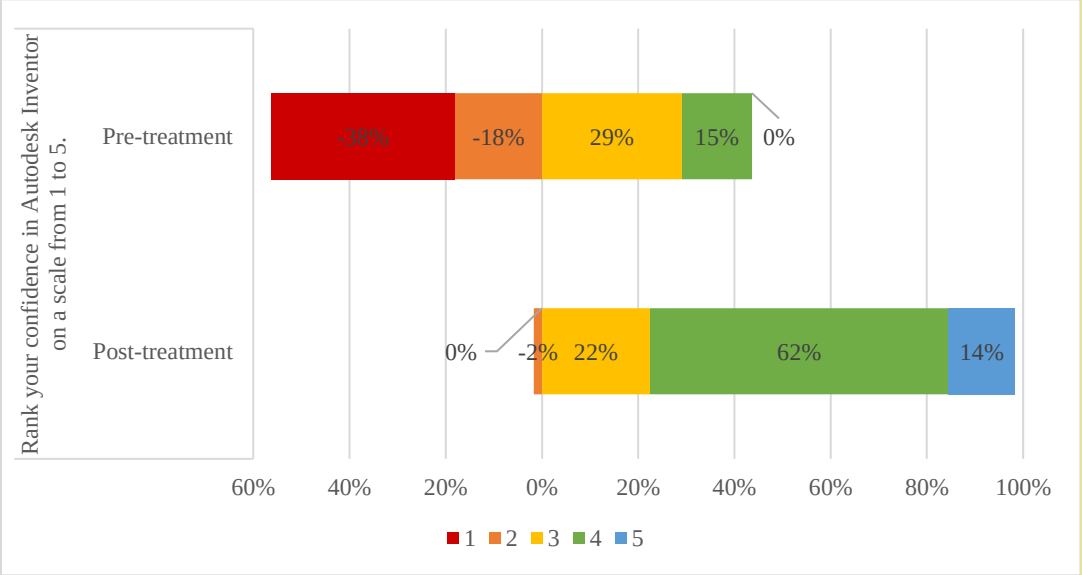


Figure 1. Autodesk Inventor confidence responses, (*N*=55, *N*=58).

For all references to groups of students, live lecture was implemented in Section 1 which will be called the non-treatment group. Section 2 and Section 3 both received video lecture instruction and will collectively be called the treatment group. Time to complete the task was the primary method for determining students' rate of mastery of the software and skills taught. Time was recorded and compared for all three activities in which students participated. The Wilcoxon Rank-Sum test was used to determine significance for all time data comparisons with an alpha level of 0.05.

The median times required for the treatment group and non-treatment group to complete the 3D Modeling Activity were 53 minutes and 67 minutes, respectively (Figure 2). The median time to complete the activity was significantly lower for the treatment group with a p-value of 0.006 (Table 2). On average, students in the live lecture group took approximately 26% longer to complete the 3D Modeling Activity when compared to the combined video lecture group. When comparing Section 2 and Section 3 independently to the non-treatment group, only Section 2 had a significantly lower median time of completion (p-value=0.003) while Section 3 had a lower median time that was not quite statistically significant (p-value=0.06). Overall, students in the treatment group mastered the software design skills in the 3D Modeling Activity more quickly than students in the non-treatment group.

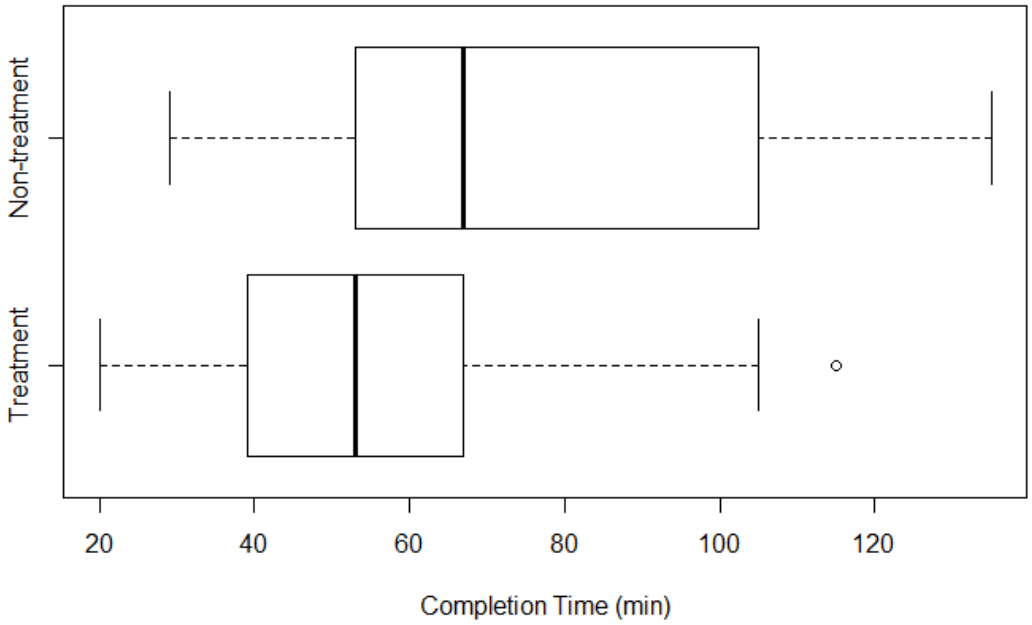


Figure 2. 3D Modeling Activity completion times, (N_{nt}=21, N_t=41).

Table 2
Wilcoxon Rank-Sum Scores for Completion Times

	P-value	Statistically Significant?
Treatment vs. Non-treatment for 3D Modeling Activity	0.006	Yes
Section 2 vs. Non-treatment for 3D Modeling Activity	0.003	Yes
Section 3 vs. Non-treatment for 3D Modeling Activity	0.060	No
Treatment vs. Non-treatment for Model Creation Activity	1.000	No
Section 2 vs. Non-treatment for Model Creation Activity	0.646	No
Section 3 vs. Non-treatment for Model Creation Activity	0.703	No
Treatment vs. Non-treatment for Test	0.014	Yes
Section 2 vs. Non-treatment for Test	0.028	Yes
Section 3 vs. Non-treatment for Test	0.038	Yes

After the initial video instruction for the 3D modeling activity, total time to complete the Model Creation Activity was recorded for students in each group. Students did not need to learn any new software design skills to complete the Model Creation Activity and they were given no further instruction, live or video, during this time. When comparing the time for completion of the Model Creation Activity, the distributions of both groups were very similar. Both the treatment and non-treatment groups had median

completion times of 60 minutes (Figure 3). The treatment group had no significant difference to the non-treatment group with a p-value of 1.00. Additionally, neither Section 2 nor Section 3 had a significant difference when compared to the non-treatment group (p=0.65, p=0.70). Even though the treatment had mastered the software skills in the 3D Modeling Activity more quickly, both groups performed equally well on the Model Creation Activity which implies the treatment and non-treatment groups were equally prepared to use the skills they had developed. Less time required to initially master the skills initially did not result in shorter completion times for the tasks in the Model Creation Activity. Students in the treatment and non-treatment seemed equally adept at transferring their software skills to a new modeling activity.

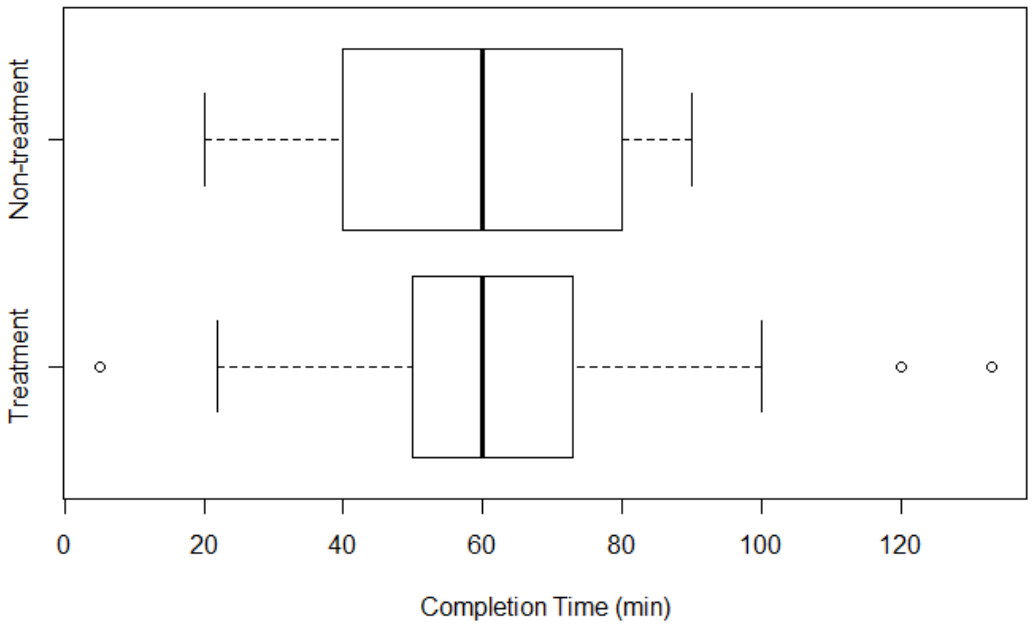


Figure 3. Model Creation Activity completion times, (N_{nt}=18, N_t=40).

Immediately after completion of the Model Creation Activity, students were timed on the 3D Modeling Test. Students were given no further instruction and were asked to model one part requiring application of their modeling skills. The 3D Modeling

Test included an element where students were required to draw an angled surface which was not asked in the other activities. When asked to identify the most difficult part of the 3D Modeling Test, many students identified this angled portion of the model. One student said, “Figuring out the slanted piece was most challenging but I figured it out.” Students in the treatment group out performed students in the non-treatment group by completing the 3D Modeling Test in a median time of 17.5 minutes while the non-treatment group took a median time of 25 minutes (Figure 4). A Wilcoxon Rank-Sum test indicated the treatment’s mean completion time was significantly lower than that of the non-treatment group ($p=0.014$). Section 2 and Section 3 had median completion times of 16.5 minutes and 18.5 minutes respectively, which were significantly lower than the non-treatment group as well ($p=0.028, 0.038$). Additionally, the distribution of student times in the treatment group had less variance when compared to the non-treatment group ($SD=8.1, 13.9$ respectively). The minimum completion time for an individual student in the treatment group and non-treatment group was both 6 minutes. However, the maximum completion time for students in the non-treatment group was 50 minutes while the treatment group was only 37 minutes. Not only did students in the treatment group outperform the non-treatment group with mean completion times, the treatment group had no students that required the full class period to complete the 3D model.

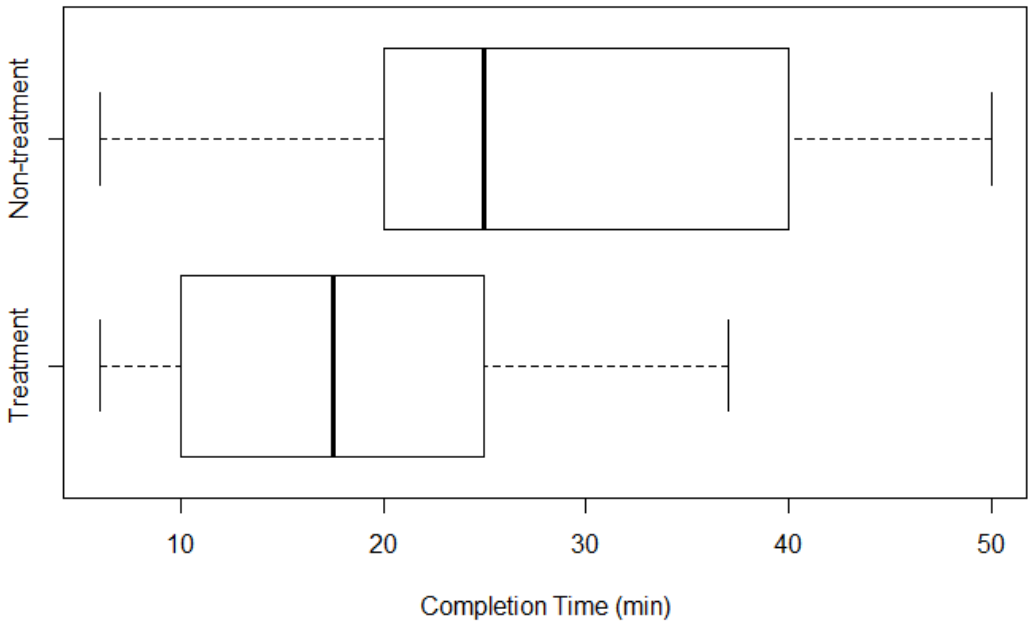


Figure 4. 3D Modeling Test completion times, (N_{nt}=18, N_t=40).

When students in either group reached a point where they could not continue without outside intervention, the instructor was able to answer questions in a one-to-one environment to address the misconceptions. Frequency of questions in each class period for each day of instruction is summarized in Table 3. The non-treatment group and treatment group averaged 0.78 and 0.47 questions per student per day, respectively. Section 2 had an average of 0.74 questions per student per day which was very similar to the non-treatment group. Alternatively, Section 3 had an average of 0.20 questions per student per day which was 74% less than the non-treatment group. The frequency of questions from day to day did show a slight decreasing trend which was understandable since new instruction only occurred on the first day of the unit (Figure 5). The treatment did not have an observable impact on the frequency of questions nor did it have an impact on students' comfort level asking questions. In the Post Treatment Likert Survey, students were asked to what extent they agreed or disagreed to the statement "I feel

comfortable asking Mr. Robbins questions when I need help in the software." No students in the treatment group or non-treatment group selected Strongly Disagree or Disagree. Students had very similar responses with 61% of students in the non-treatment group and 63% of students in the treatment group selecting Strongly Agree (Figure 6). While the frequency and comfort of questions did not demonstrate observable differences, the treatment seemed to have impacted the type of questions students asked. The instructor's observation notes indicated that students in the treatment group asked very specific questions in regard to the commands in the software while the students in the non-treatment group asked more general questions about how to complete a task. Referring to the treatment group the instructor wrote, "Questions are much more specific and focused on the task." The instructor also noted frustration with students in the non-treatment group asking questions that were clearly addressed in the live lecture only minutes before. Students in the treatment with access to the video lecture were less likely to ask questions that were already answered in the video because they could rewind and replay the video lecture.

Table 3
Frequency of Student Questions

	Day 1	Day 2	Day 3	Day 4	Day 5	Average
Section 1 - Live Lecture	0.83	0.79	1.04	0.58	0.63	0.78
Section 2 - Video Lecture	1.26	0.70	0.65	0.65	0.43	0.74
Section 3 - Video Lecture	0.32	0.10	0.03	0.42	0.13	0.20
Combined Video Lecture	0.81	0.53	0.58	0.55	0.40	0.57

Note. All values are measured in questions/student/day.

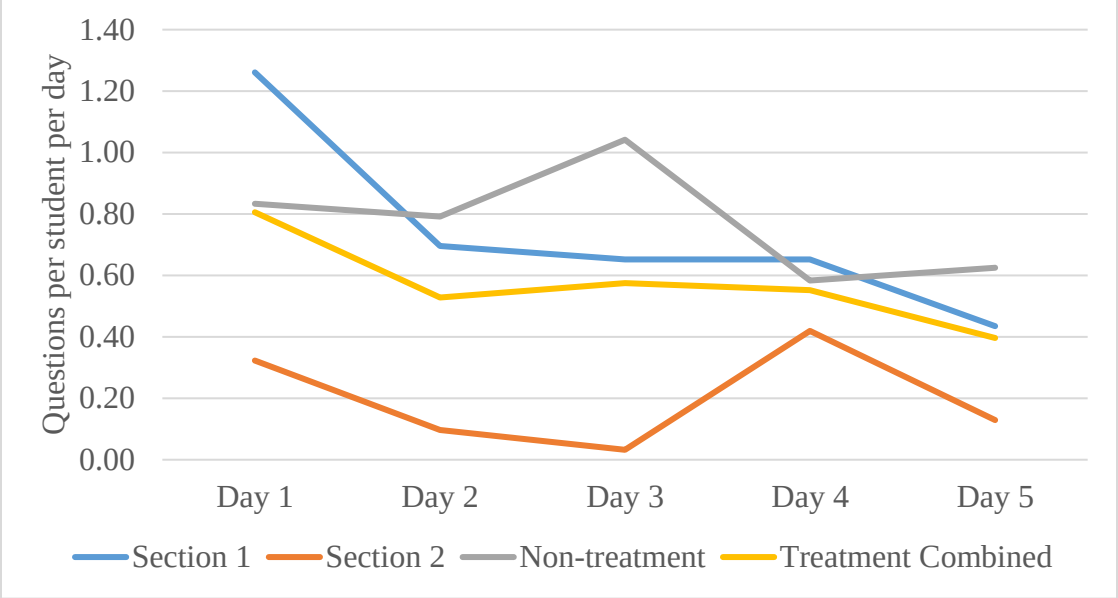


Figure 5. Line graph of student question frequency.

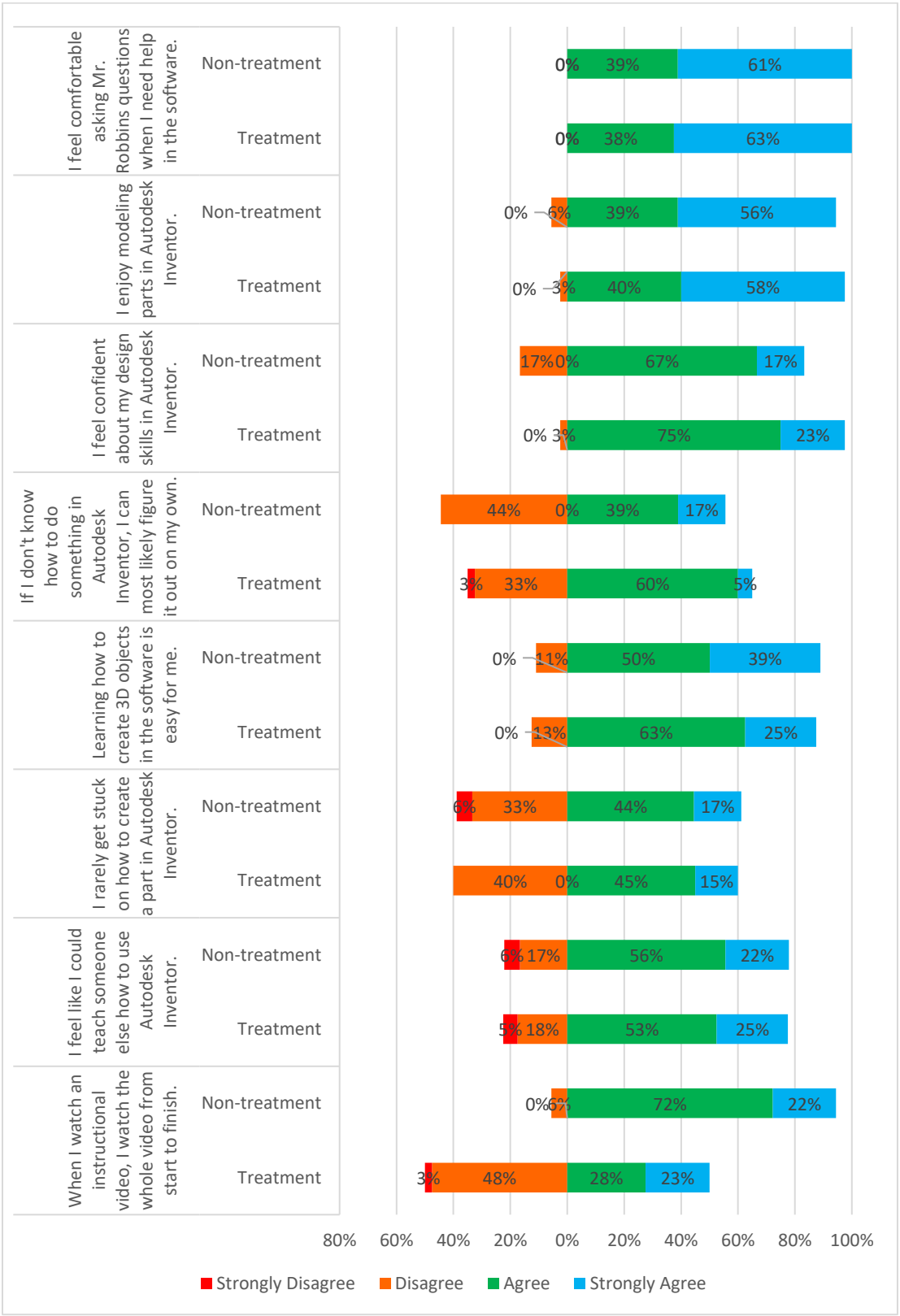


Figure 6. Stacked bar chart of selected post treatment Likert survey questions.

Student engagement data was recorded by documenting the number of students off task every 15 minutes throughout the class period. Based on the length of class periods, each period had three data values for number of students off task. The total of these tallied values was computed and converted into a percentage of students off task for each section for each day (Table 4). Engagement was slightly higher for the treatment at 97% on task when compared to the non-treatment group at 89% on task. Due to the low count of data in categories, a Fisher's Exact Test was used to compare the treatment and non-treatment groups using total student counts of on-task and off-task over the five days. While the treatment group had higher engagement, it was not statistically significant with a p-value of 0.08. However, Section 3 had a significantly higher engagement than the non-treatment group with a p-value of 0.03. The variance observed between sections cannot be attributed to the treatment.

Table 4
Percentage of Students On-Task by Day

	Day 1	Day 2	Day 3	Day 4	Day 5	Average % Off Task	Average % On Task
Non-treatment	4%	9%	0%	0%	9%	4%	96%
Section 1 - Treatment	0%	0%	6%	6%	0%	2%	98%
Section 2 - Treatment	8%	17%	13%	8%	8%	11%	89%
Combined Treatment	2%	4%	3%	3%	4%	3%	97%

Note. Percentages were calculated by taking the total number of students tallied as off task at 15-minute intervals as a percent of the total students in the class.

When asked on the Post Treatment Likert Survey to what extent students enjoyed modeling in Autodesk Inventor, the non-treatment and treatment groups both responded

favorably with nearly identical proportions choosing Agree and Strongly Agree (Figure 6). In the post treatment Student Interview Questions, 20% of students voluntarily made a comment about how much they enjoyed the class and learning the software. One student stated, “Autodesk Inventor was really fun.” Students in the treatment group tended to be more agreeable with the statement “I feel confident about my design skills in Autodesk Inventor” with 98% choosing Agree or Strongly Agree compared to 84% in the non-treatment group. When asked if students could figure something out on their own in the software, students in the treatment group were slightly more agreeable than the non-treatment group. The treatment and non-treatment groups responded similarly when asked if learning the software was easy with over 80% of students choosing Agree or Strongly Agree. Additionally, students in the treatment group and non-treatment group responded similarly to the statement “I rarely get stuck on how to create a part in Autodesk Inventor” with approximately 60% of students choosing Agree or Strongly Agree. Students in the treatment and non-treatment groups demonstrated equal confidence levels in their ability to teach someone else how to use Autodesk Inventor with over 75% of students in each group stating they Agree or Strongly Agree that they could teach someone else. Interestingly, students in the treatment group were much more likely to choose Strongly Disagree or Disagree to the statement “When I watch an instructional video, I watch the whole video from start to finish.” Even though students in the non-treatment group did not watch instructional videos in this unit, 94% stated that they agreed that they would watch them from start to finish.

Based on survey results, students demonstrated a strong positive disposition towards video lecture. In the Post Treatment Likert Survey, 96% of students in the treatment group agreed the video instruction was clear and easy to follow (N_t=40). Additionally, 91% agreed the instructional videos helped them learn how to model in the software. The majority of students, 81%, agreed to the statement "I liked the instructional videos." In the post treatment Student Survey, 66% of students chose video lecture as their preferred instructional method when learning something new. Of this group of students, 92% justified their decision by referring to the adaptability of video lectures to individual learning needs. Students recognized one of the benefits of video lecture is its ability to go at the pace of the learner. One student stated, "I prefer a video because that way I can go at my own pace by skipping ahead or going back to look at things that I don't understand." When asked whether playback of the instructional videos was adapted such as pausing, rewinding, or skipping ahead, 96% of students in the treatment group chose Agree or Strongly Agree. This perspective on video lecture was not developed during this class. When asked specifically what students liked best about video lectures on the pre-treatment Student Interview, 47% indicated they liked the opportunity to rewind and replay the lecture and 20% indicated video lectures allowed them to go at their own pace by pausing the video or speeding it up. Students were quick to note the live lectures do not provide this type of adaptability. When asked what students liked least about live lecture on the post-treatment Student Interview, many students referred to the fact you cannot replay the lecture or change the pace of instruction. One student

stated, “If you are far ahead or behind of everyone else he [the instructor] can’t adjust the speed for you specifically, they [instructors] have to do it for the good of the class.”

When students were asked to identify what they like least about video lecture, many students stated not being able to ask questions or get further detail about a topic. Several students also identified the possibility of a video lecture not being accessible due to technical problems such as internet connection. A handful of students stated that video lecture was difficult using a single computer monitor because it required the use of split screens. When asked what students like most about live lecture, the majority of students, 59%, stated live lecture allows you to ask questions and have instruction instantly adapted by changing the speed or depth of detail to the audience’s needs. When asked what students liked best about live lecture on the pre-treatment Student Interview, the majority of students (65%) stated live lecture allowed them to ask questions while video lecture did not allow any additional questions beyond what was already recorded.

Student preference towards video lecture or live lecture instruction remained unchanged after the unit. On the post treatment Student Survey, 60% of students preferred a combination of both live lecture and video lecture, 30% preferred solely video lecture, and 10% chose solely live lecture (Figure 7). As shown in Figure 5, the distribution of responses for the treatment group on the post-treatment survey was very similar to the pre-treatment survey. Due to the low count of data in categories, a Fisher’s Exact Test was used to compare the treatment to the non-treatment group. A Fisher’s Exact Test was also used to compare the pre-treatment to post-treatment responses for both the non-treatment group and treatment group. None of the pairs of response data had

significantly different distributions with p-values scoring 0.18 or higher. Students' preference for video lecture remained proportionally higher than live lecture throughout this study. The treatment did not significantly impact instructional method preference.

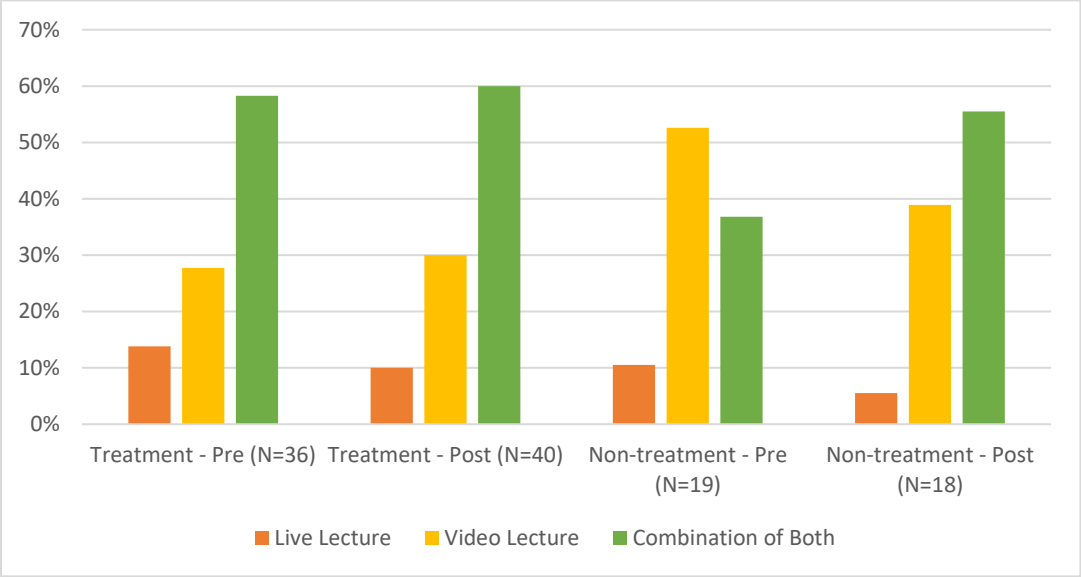


Figure 7. Student preferred method of instruction pre- vs. post-.

INTERPRETATION AND CONCLUSION

The primary research question for this study asked, what are the effects of video lecture instruction when compared to traditional instruction on students' rate of mastering three-dimensional computer-aided design software? Task completion time recorded for the 3D Modeling Activity, the Model Creation Activity, and the 3D Modeling test indicates there was a significant difference in the rates of student mastery of the software. When learning new skills in the computer-aided design software during the 3D Modeling Activity, students in the treatment group had significantly lower median completion times when compared to the non-treatment group. Since both groups had similar baseline experience in the modeling software, the results indicate video lecture did positively impact students' rate of mastery when compared to live lecture. It can be inferred the

increase in rate of mastery may be attributed to the fact that students can learn at their own pace, complete the task while simultaneously watching instruction, and repeat instruction as many times as desired. Interestingly, if the 15 minutes of instructional time were removed from the completion time for the non-treatment group, there would be no significant difference in median completion times when comparing the non-treatment and treatment groups for the 3D Modeling Test. A Wilcoxon-Rank Sum test for this scenario resulted in a p-value of 0.53. While the live instruction time was necessary for the non-treatment group to succeed, it can account for the difference in completion times between the two groups. The video instruction was more efficient than live lecture. For procedural knowledge such as learning a new software, multiple researchers have demonstrated that students' rate of mastery increases for video-based instruction when compared to other instructional methods (Berney & Bétrancourt, 2016; Palmiter & Elkerton, 1993; van der Meij & van der Meij, 2013). My classroom research supports using video lecture instruction over live lecture instruction for software skill development.

While it took less time for video lecture students to learn the software skills initially, all students performed equally well on tasks in the Model Creation Activity immediately afterwards. This suggests both instructional methods have the same immediate effect on student mastery with the software even though the time required to accomplish this differed. However, instructional time cannot explain the difference in completion times for the 3D Modeling Test which the treatment group completed in significantly less time. The data suggests video lecture increased students' retention and ability to transfer skills to a new task days later. Video lecture seems to have increased

students' retention and/or ability to transfer skills to new scenarios. On average, students in the non-treatment group took 30% longer to complete the 3D Modeling Test. Because the test required students to transfer their procedural knowledge in a new application, namely a slanted surface, it was difficult to discern whether this difference in completion time was due to greater retention or increased ability to transfer knowledge. Independent research by van der Meij and van der Meij (2014) showed students receiving video-based instruction had greater retention rates than students with a text-based instruction when tested a week later. In my classroom research, students receiving video-based instruction showed greater retention and ability to transfer skills when compared to live lecture. Video lecture demonstrated short-term benefits by taking less time and long-term results for student achievement.

A secondary goal of this research focused on determining the effects of video lecture instruction on student engagement and frequency of student-to-teacher questions. The data suggested no significant change in student engagement. According to instructor observations, video lecture may have provided a singular focus for some students but distractions and lack of motivation were still apparent despite the instructional method. Nevertheless, the qualitative data collected through instructor notes during each class period suggests video lecture increased the specificity of student-to-teacher questions. Video lecture provides students opportunity to get quick answers to general questions by replaying the video. Students in the live lecture were more prone to ask general questions about the task because they understandably did not retain every piece of information from the live lecture. If less instructor time is allocated to answering general student questions,

the instructor can more efficiently address specific student questions which will increase the rate of learning in the classroom. Additionally, one could infer the depth of learning is greater for students that are able to formulate a specific question rather than spending time seeking answers to general questions. If this study were to be extended, time required to answer student questions and wait time to get a question answered could be recorded and evaluated to better understand the relationship between video lecture, the type of student questions asked, and the effect on task completion time.

As an overarching theme, the data from student surveys and interviews suggest that students prefer to have access to video lecture when learning something new. This preference was consistent on the pre-treatment and post-treatment surveys for all students. The treatment had no significant effect on students' positive preference toward video lecture (Figure 5). When the student population is considered as a whole, 91% of students on the post survey stated video lecture instruction or a combination of video and live lecture instruction "worked best" for them (N=58). One third of students preferred video lecture instruction alone while only 9% of students preferred live lecture alone. Students preferred video lecture because of its adaptability to their own learning pace. Eighty eight percent of students at some point on the post survey identified adjustable playback as a key benefit of video lecture. Adaptability may be one of the most beneficial features of video instruction and is a primary reason why students prefer it. Adaptable playback has been shown to increase student achievement in an independent study with procedural knowledge (van der Meij & van der Meij, 2013). The data and results of this

classroom research support the beneficial aspects of adaptable video playback as increasing student disposition towards video lecture and impacting student achievement.

VALUE

The most readily apparent impact of this study alters the way I will implement video-based instruction into my classroom in the future. The background research for this study has provided me a framework for understanding the most effective characteristics of video-based instruction and the types of learning it is best suited for. In the study, I applied the model as outlined by van der Meij and van der Meij (2013) of providing a task preview at the beginning of the video and attempting to create videos as short as possible. I have already successfully used this model of video instruction in developing videos for my chemistry and physics courses for selected topics. While this study focused on videos for procedural knowledge, independent research has demonstrated the effectiveness of video based instruction for more complex topics such as those found in an Advanced Placement chemistry or physics course (Lloyd & Robertson, 2012; Yi et al., 2012). Based on my classroom research results, students find video based instruction valuable to their learning. I plan to continue improving upon the use of video based instruction in the high school science classroom to enhance the learning environment for students.

The results of this study have prompted questions regarding video based lecture that require further study. Some views of education suggest that the live teacher will eventually be replaced by technology. While this study supports the use of technology in the classroom, I believe it also defends the importance of teachers in the classroom as a

very influential component of student success. While video lecture provides the ability to change the pace and repeat instruction, it offers no ability to adapt the modality or pedagogy of instruction to a particular learner or learning environment. This integral piece of education is most effectively filled by a person, namely a teacher. The ability of a teacher to adapt to a learning environment far exceeds that of a video. It is true a teacher cannot teach a lesson at 25 different speeds and repeat it multiple times in a 50-minute class period. Video lecture is delivery method that can provide this to students when necessary and should be used to do so. A teacher, however, provides differentiated instruction with unique passion and a special set of pedagogical skills developed over years of practice that creates a unique learning environment that is tailored to the present state of learners in the classroom at any given point in time. While students may not have the ability to fully verbalize the role and importance of a teacher in the classroom, the students in this study observed the importance of an expert being present to answer their individual questions. One student said, “I prefer a live presenter because if I need to ask questions or need something explained in more depth I can just ask.” Ninety percent of students in the post survey identified being able to ask questions and access differentiated instruction as a primary benefit of a teacher that cannot be provided by a video. The majority of students (58%) preferred a combination of both live lecture and video lecture on the post Student Interview Questions (N=58). The question should not be, do we use video lecture or live lecture? A better question is, to what extent should video lecture be used to maximize its positive effects as a tool in instruction? This question deserves further investigation beyond this study.

The most significant impact of this study on my teaching practice comes from the process of action research. I have been reminded that teaching is dynamic. The action research process required me to focus intently on the students in my classroom, learning their preferences and dispositions toward my instructional practices and content delivery. One of my roles as a teacher is to learn each individual class' preferences and natural dispositions so as to tailor my instructional practices to create a learning environment with the greatest efficacy for that group of students. I was reminded in this study the importance of qualitative student feedback. Often, I continue in practice without getting feedback other than the numerical data I collect in class. I currently implement surveys one or two times per year that ask broad questions about the course as a whole and work to find general trends. This study has demonstrated the value of frequently collecting qualitative survey data for a specific purpose throughout each course to help guide decisions. Throughout this process I have learned to use statistical tests and software packages that will significantly decrease the amount of time required to find meaningful trends in future collected data. The action research process can be used to inform decisions in the classroom without requiring full data reports. I now have the skillset to collect data that is specific to my classroom and analyze the results to help inform my teaching practices. Using current educational research as a foundation for the instructional decisions I make in the classroom, I can now analyze the efficacy of this research in my specific environment by implementing the action research model.

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APPENDICES

APPENDIX A

INSTITUTIONAL REVIEW BOARD EXEMPTION

INSTITUTIONAL REVIEW BOARD

For the Protection of Human Subjects
FWA 00000165

MONTANA STATE UNIVERSITY

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MEMORANDUM

TO: Austin Robbins and John Graves

FROM: Mark Quinn Mark Quinn Chy
Chair, Institutional Review Board for the Protection of Human Subjects

DATE: November 27, 2017

RE: *"The Effects of Video Lecture Instruction on Students' Mastery of Three-Dimensional Design Software"* [AR112717-EX]

The above research, described in your submission of November 20, 2017, is exempt from the requirement of review by the Institutional Review Board in accordance with the Code of Federal regulations, Part 46, section 101. The specific paragraph which applies to your research is:

_X_ (b) (1) Research conducted in established or commonly accepted educational settings, involving normal educational practices such as (i) research on regular and special education instructional strategies, or (ii) research on the effectiveness of or the comparison among instructional techniques, curricula, or classroom management methods.

_X_ (b) (2) Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures or observation of public behavior, unless: (i) information obtained is recorded in such a manner that human subjects can be identified, directly or through identifiers linked to the subjects; and (ii) any disclosure of the human subjects' responses outside the research could reasonably place the subjects at risk of criminal or civil liability, or be damaging to the subjects' financial standing, employability, or reputation.

___ (b) (3) Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures, or observation of public behavior that is not exempt under paragraph (b)(2) of this section, if: (i) the human subjects are elected or appointed public officials or candidates for public office; or (ii) federal statute(s) without exception that the confidentiality of the personally identifiable information will be maintained throughout the research and thereafter.

____ (b) (4) Research involving the collection or study of existing data, documents, records, pathological specimens, or diagnostic specimens, if these sources are publicly available, or if the information is recorded by the investigator in such a manner that the subjects cannot be identified, directly or through identifiers linked to the subjects.

____ (b) (5) Research and demonstration projects, which are conducted by or subject to the approval of department or agency heads, and which are designed to study, evaluate, or otherwise examine: (i) public benefit or service programs; (ii) procedures for obtaining benefits or services under those programs; (iii) possible changes in or alternatives to those programs or procedures; or (iv) possible changes in methods or levels of payment for benefits or services under those programs.

_____ (b) (6) Taste and food quality evaluation and consumer acceptance studies, (i) if wholesome foods without additives are consumed, or (ii) if a food is consumed that contains a food ingredient at or below the level and for a use found to be safe, or agricultural chemical or environmental contaminant at or below the level found to be safe, by the FDA, or approved by the EPA, or the Food Safety and Inspection Service of the USDA.

Although review by the Institutional Review Board is not required for the above research, the Committee will be glad to review it. If you wish a review and committee approval, please submit 3 copies of the usual application form and it will be processed by expedited review.

APPENDIX B

STUDENT INTERVIEW QUESTIONS

1. My experience in Autodesk Inventor could be summarized as…
    a. I have no experience in the program
    b. I have some experience in the program
    c. I am very experienced in the program
2. When modeling parts in Autodesk Inventor, I feel like I can…
    a. Not model any type of 3D part
    b. Model only 3D parts with very basic shapes
    c. Model complex parts based on their dimensioned drawings
3. My confidence in Autodesk Inventor can be summarized as…
4. When learning something you don't know, do you prefer a live presenter or a video? Why?
5. Which instructional method works best for you, video lectures or live lectures?
6. What do you like best about video lectures? What do you like least?
7. Is there anything else you would like me to know?

APPENDIX C

SOFTWARE MODELING INTRODUCTION

PLTW | Engineering

Introduction

3D computer modeling is a powerful tool for engineers. It allows an idea to be translated into a model that can communicate the concept and adapt to changes. The 3D computer model can even be used to create a physical model with devices such as a 3D printer or a mill.

In this activity you will learn the basic Autodesk® Inventor® software interface and file management. This orientation is important to allow efficient modeling of your own ideas.

Equipment

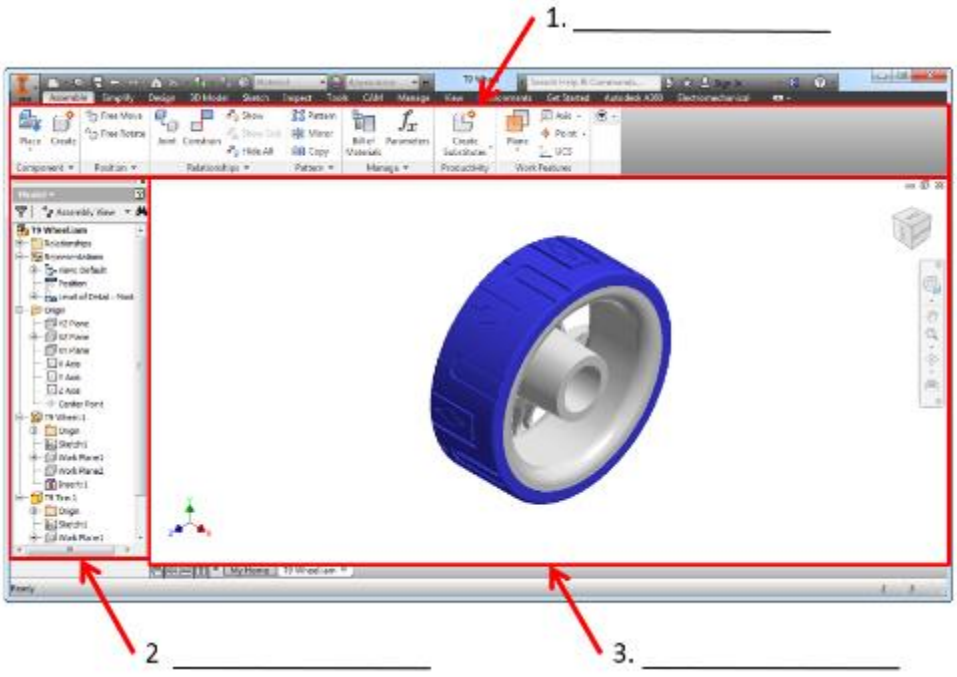
- Engineering notebook
- Computer with 3D computer-aided design (CAD) software (such as Autodesk® Inventor®)
- Autodesk® Inventor® videos
  - UI Navigation 1
  - UI Navigation 2
  - Navigation Control
  - Project Files
  - Part Browser

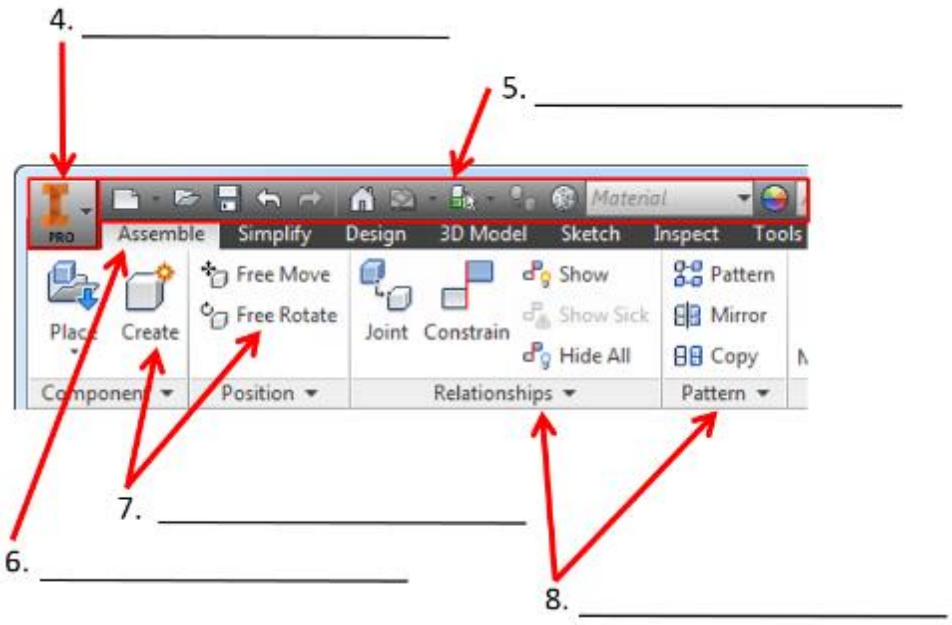
Procedure

1. Open Autodesk® Inventor®. To explore the three Inventor templates represented on the opening screen, hover over each icon.
2. Complete the following table with a description of the template and the file extension used for each file type.

Inventor Environment	File extension	Description
Part		
Assembly		
Drawing		

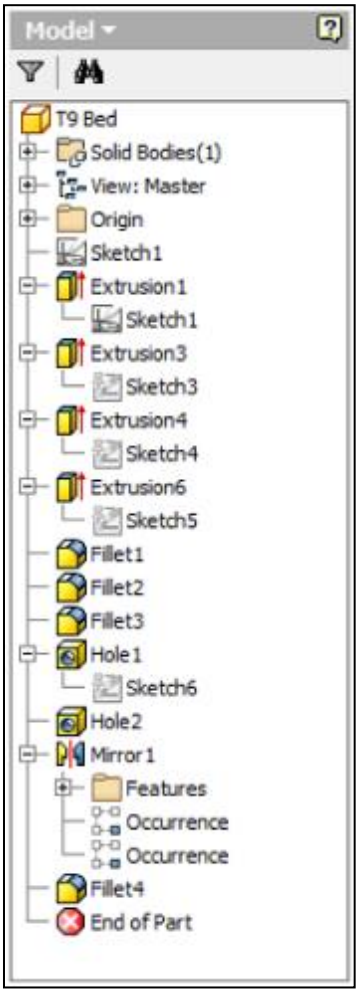
Label the features of the user interface in the following images.





2. How do you restore the browser if lost?

3. View the Inventor tutorial Part Browser. Use the following part browser display to answer the questions that follow.

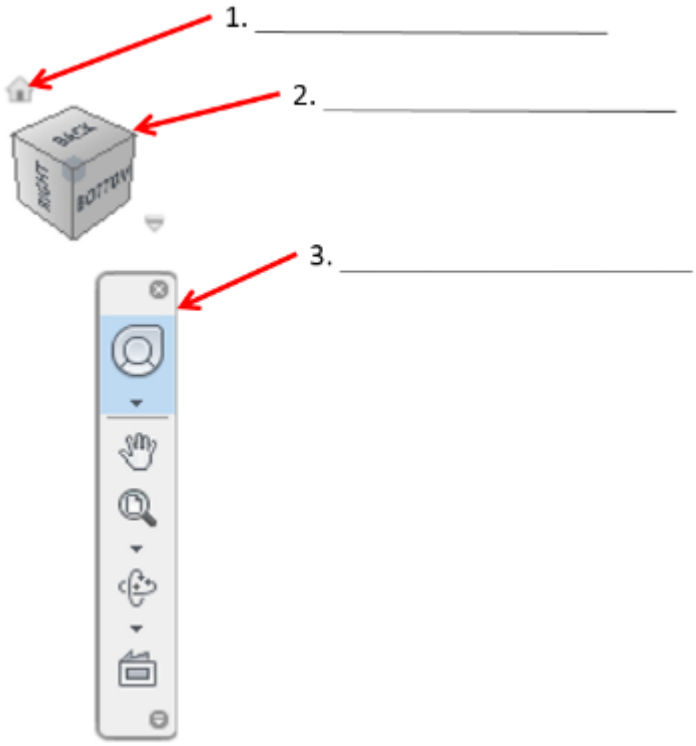


   a. Which feature was likely created first, Hole 1 or Extrusion 3? Explain your answer.

   b. How do you share a sketch in an Inventor part file?

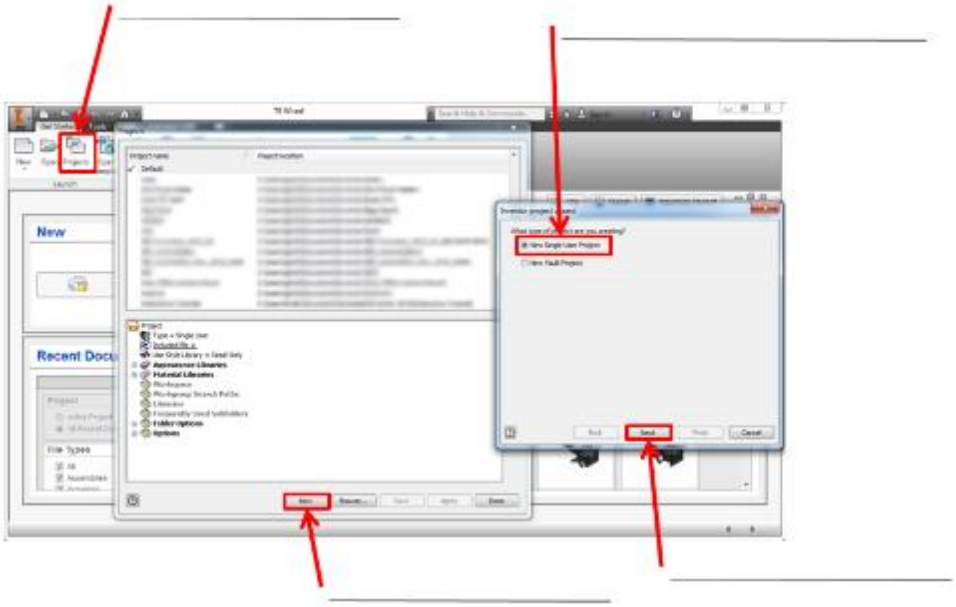
   c. Which sketch is shared in the part file? Explain your answer.

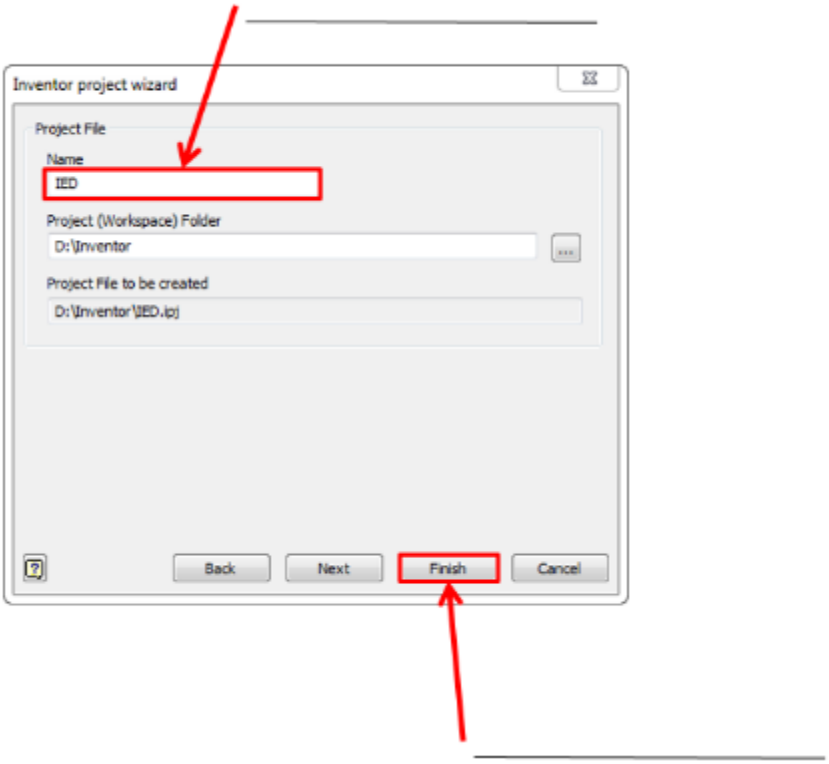
4. View the Inventor tutorial Navigation Controls. Label the navigation controls in the following image.



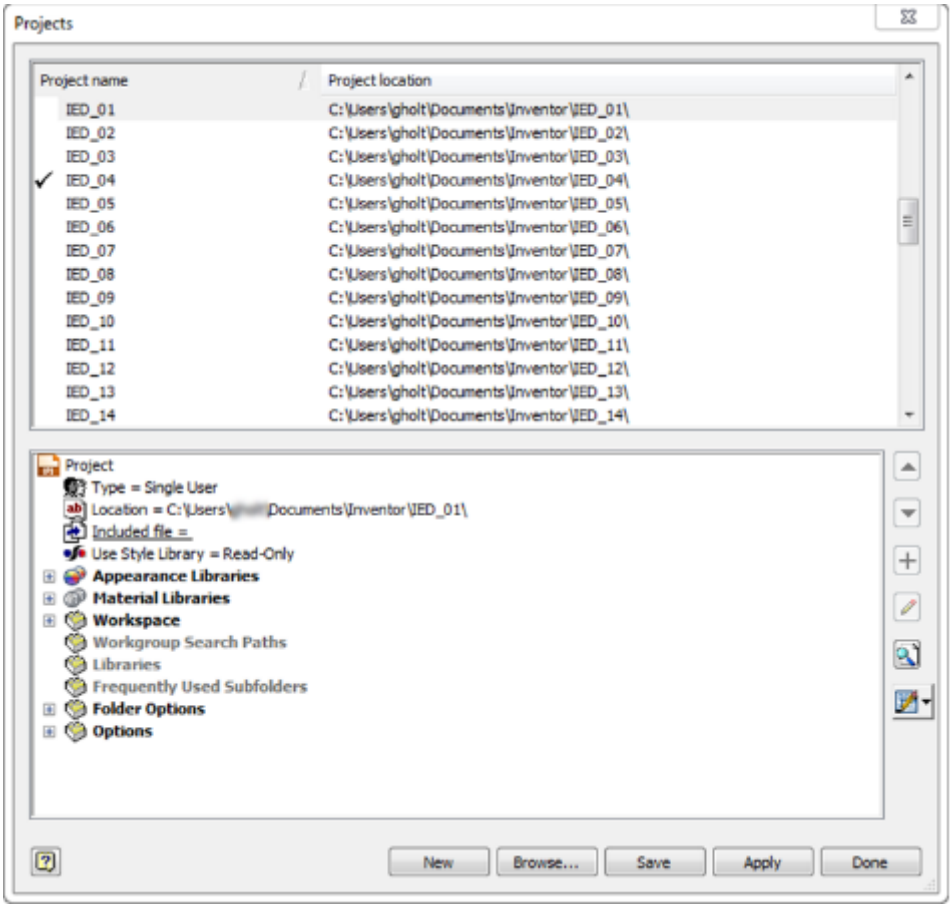
5. Describe the functions available with each of the following function keys.
   - **F2** _____
   - **F3** _____
   - **F4** _____
   - **F5** _____
   - **F6** _____

6. View the Inventor Tutorial video Project Files. Then address the following items.
    a. Label the following images with the correct sequence of steps to set up a project without Libraries.




Inventor project wizard
Project File
Name
IED
Project (Workspace) Folder
D:\Inventor
Project File to be created
D:\Inventor\IED.ipj
Back
Next
Finish
Cancel

b. What is the active project in the following image?



c. How could IED_01 be made the active project?

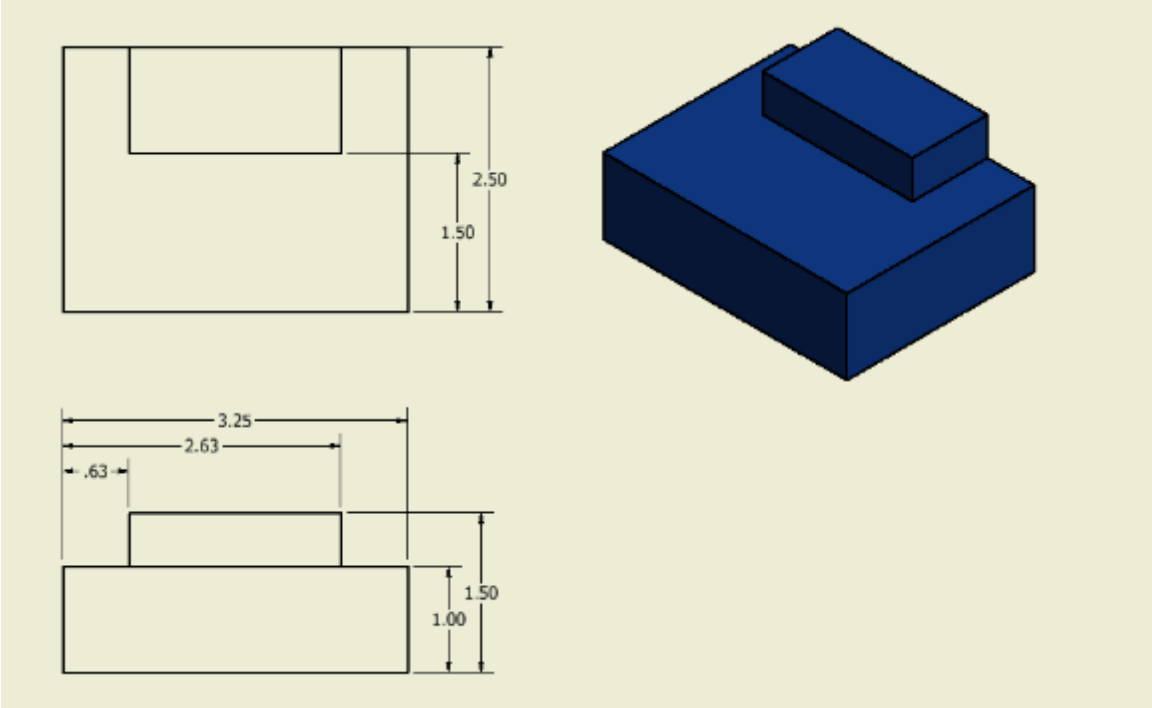
Conclusion Questions

1. Why is using the vocabulary presented in the tutorials important?
2. Why is it important to properly select the project each time a model is created?

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APPENDIX D

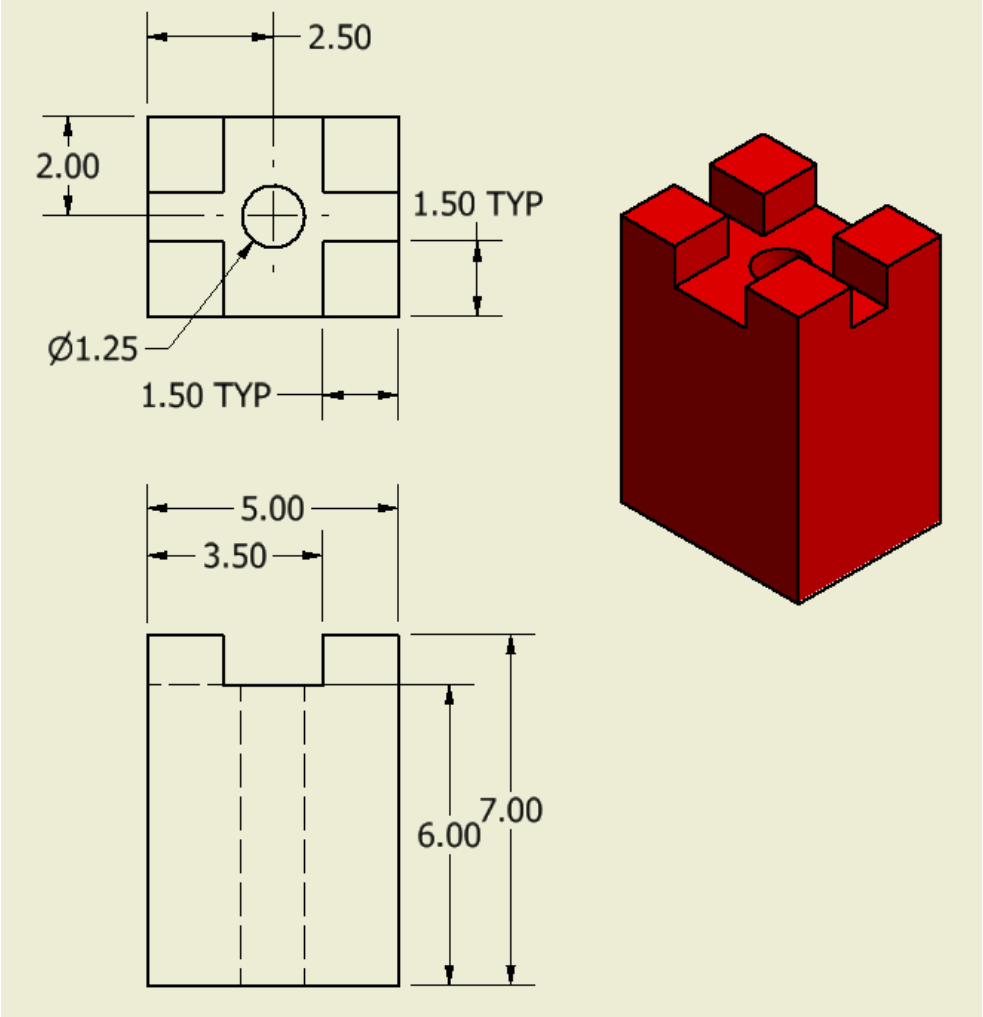
VIDEO OBJECT 1



https://youtu.be/TLPuYKrO_uM

APPENDIX E

VIDEO OBJECT 2



https://youtu.be/RSh9ei8vL18

APPENDIX F

MODEL CREATION ACTIVITY

Introduction

To effectively use a CAD program to create 3D models of a part, a designer must be familiar with the basic strategies of additive and subtractive modeling methods. This activity will help you understand the sketching tools and extrusion features that are common to most CAD programs, plan an efficient method of simple model creation, and gain experience creating simple 3D models.

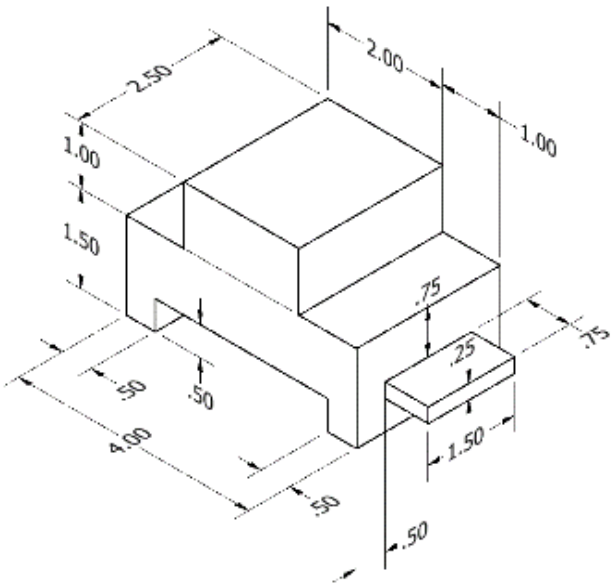
Equipment

- Computer with 3D CAD solid modeling program

Procedure

Follow the instructions to create 3D solid models of each of the following objects using the specified method(s) and respond to the prompts.

1.

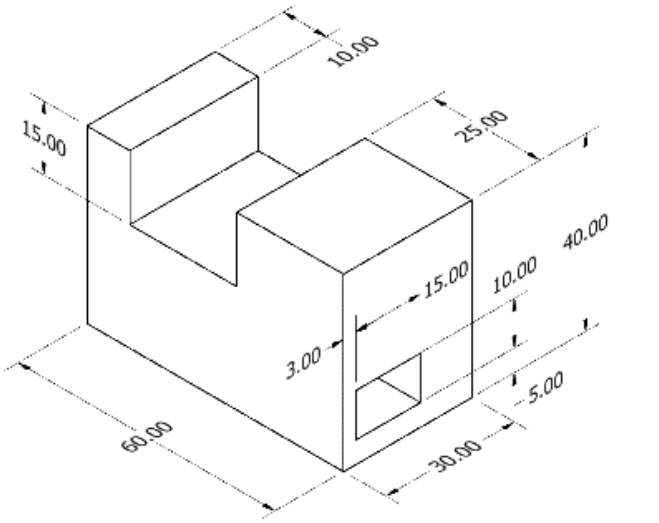


All dimensions are in inches.

a. Create a 3D solid model of the object above using the most efficient method.

b. Which method (additive, subtractive, or a combination of additive and subtractive) did you use? Why do you feel it was most efficient?

2.

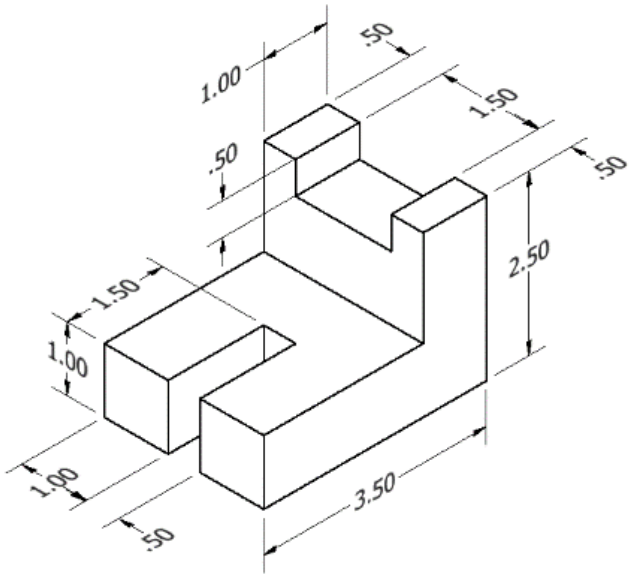


All dimensions are in mm.

a. Create a 3D solid model of the object above using the most efficient method possible.

b. Describe the method you used to model the object. Why do you feel it was most efficient?

3.

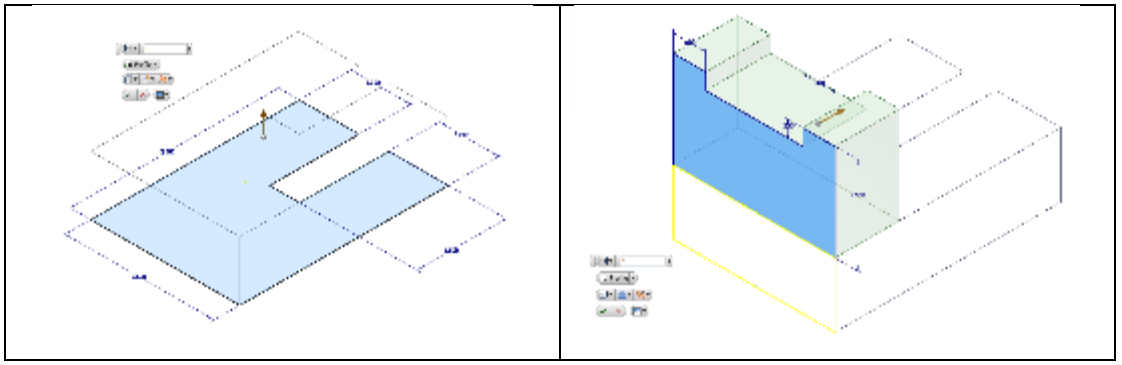


All dimensions are in inches.

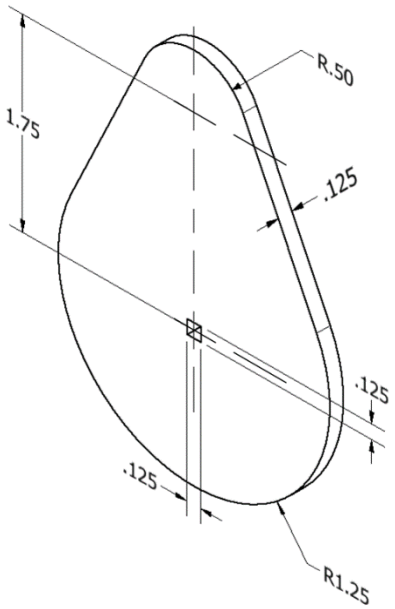
a. Create a 3D solid model of the object above using only additive procedures.

b. Create a 3D solid model of the object above using only subtractive procedures.

c. Which method (additive, subtractive, or a combination of additive and subtractive) do you feel would be the most efficient method for creating the object? Why?

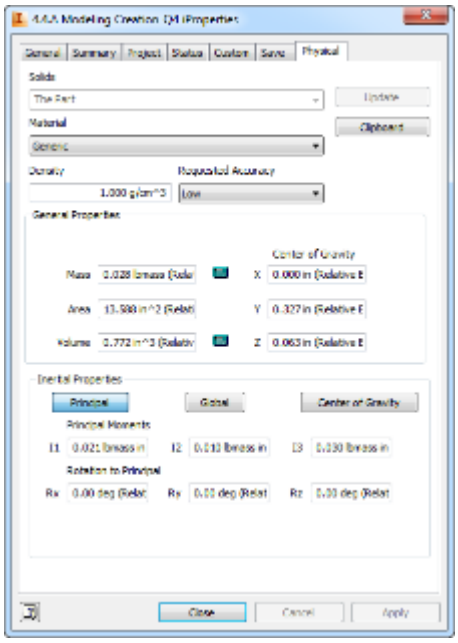


4.



All dimensions are in inches.

a. Create a 3D solid model of the object above.



b. Describe the method you used to create the object.

c. Explain the most efficient procedure using a single extrusion to create this 3D solid model.

Conclusion

4. Why is it important to consider efficiency when planning your method of creation before you begin to model an object in CAD?
5. How can the information provided in the browser of the CAD software help you compare the efficiency of two different methods of modeling the same object?

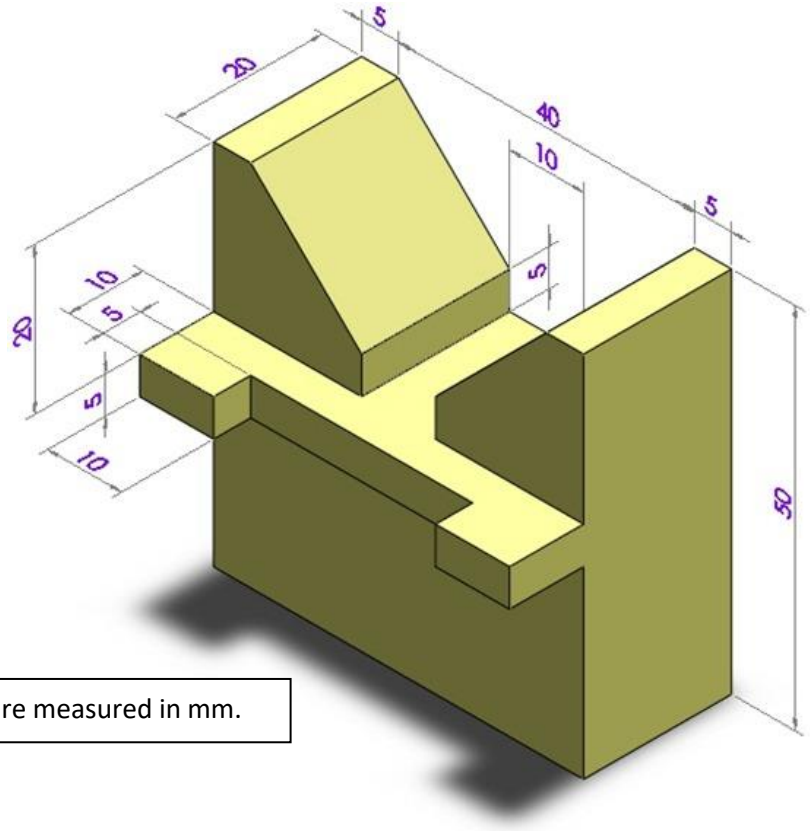
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APPENDIX G

3D MODELING TEST

3D Modeling Test

Create the part below in Autodesk Inventor using the dimensions given. You must complete this part individually and may **not** talk with a neighbor during this class period. When you are finished with the model, record the time required for you to complete the model. Then answer the questions below and turn in to the substitute. Your model will be checked by Mr. Robbins tomorrow.



All Units are measured in mm.

1. Time required to complete the model of the part: _____.
2. Which method (additive, subtractive, or a combination of both) did you use?
3. What method do you think is the most efficient way to model this part? Why do you feel it is?
4. Was there any part of the model you struggled to create?

APPENDIX H

POST TREATMENT LIKERT SURVEY

Please read each of the statements below and indicate the extent to which you agree or disagree with the statement. Only consider the Autodesk Inventor features we have learned in class (not any extra projects you are working on).

	Strongly Agree	Agree	Disagree	Strongly Disagree
1. I feel confident about my design skills in Autodesk Inventor.				
2. I enjoy modeling parts in Autodesk Inventor.				
3. Instructional videos help me learn how to model in Autodesk Inventor.				
4. I feel comfortable asking Mr. Robbins questions when I need help in the software.				
5. When I watch an instructional video, I watch all of the video.				
6. The instruction in the videos was clear and easy to follow.				
7. I would adapt the playback of instructional videos (replay, slow down, speed up) as I watched them.				
8. If I don't know how to do something in Autodesk Inventor, I can most likely figure it out on my own.				
9. Learning how to create 3D objects in the software is easy for me.				
10. I rarely get stuck on how to create a part in Autodesk Inventor.				
11. I feel like I could teach someone else how to use Autodesk Inventor.				
12. I liked the instructional videos.				