ASEE 2022 ANNUAL CONFERENCE
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MINNEAPOLIS, MINNESOTA, JUNE 26TH-29TH, 2022 ASEE
Paper ID #37238

Benefits of Video Tutorials for a Computer Aided Design Class

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Benefits of Video Tutorials for a Computer Aided Design Class

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Type of paper: Evidence-Based Practice

Abstract

Introduction to Engineering II (ENCP A102) at University of South Carolina Aiken is a computer-aided design (CAD) class using Creo Parametric, a feature-based solid modeling program. In spring 2019, the author instructed students in a traditional classroom setting, going step-by-step through the first ten lessons in Toogood [1]. However, in spring 2020 when classes shifted online due to the pandemic, the author decided to shift his instruction to a recorded video format. This approach provided students with more flexibility and a greater sense of control over their learning process. Students responded very well to this approach and performed better, on average, than in 2019. The recorded video approach also seemed to align well with the attention to detail required for computer modeling. Therefore, the author used this video tutorial approach even more extensively in the 2021 spring semester. Students once again responded well and performed better, on average, than students in the previous two years.

Keywords

Computer aided design (CAD), video recorded lessons, feature-based solid modeling

Introduction

The second Introduction to Engineering course (ENCP A102) at University of South Carolina Aiken (UofSC Aiken) is a computer aided design (CAD) class wherein students learn to create three-dimensional (3D) views and two-dimensional (2D) drawings of mechanical components in Creo Parametric, a feature-based solid modeling program. Most of the students in ENCP A102 are freshman students who are either committed to an engineering education or are at least strongly considering it. In the 2019 spring semester (SP19), the author instructed students in a traditional classroom setting, going step-by-step through the first ten lessons of Toogood [1]. In the 2020 spring semester (SP20), the class began with the same approach but when classes shifted online due to the pandemic, the author decided to shift his instruction to a recorded video format. This approach provided students more flexibility and a greater sense of control over their schedule and learning process, which the author felt was important to their well-being during the early stages of the pandemic. The author also thought that the recorded video approach would align well with the attention to detail required for creating parts and drawings in Creo. Students responded very well, performing better on average than students in the previous year. Additionally, the author received many positive comments from students. Therefore, the author decided to use this video tutorial approach throughout the 2021 spring semester (SP21). With classes now back in a physical classroom, students were asked to bring in headphones to watch

the video tutorials at their own pace. Students once again responded with positive feedback and performed better, on average, than students in the previous two years.

In previous research in this area, Abdulrasool *et al.* [2] found that integrating computer simulations with traditional classroom teaching of Computer Aided Design (CAD), Computer Aided Manufacturing (CAM), and Computerized Numerical Control (CNC) technologies improved the learning effectiveness of students. This outcome was determined by having two groups of students, one that received traditional classroom teaching and the other whose instruction was augmented with computer software assisted instruction. Both groups were evaluated to have very similar "pre-learning indicators" and the group that received the computer assisted instruction scored significantly higher for five different learning outcomes. Noviyanta and Ngadiyono [3] created video tutorials to instruct students in an Indonesian Vocational High School on how to create manufacturing drawings using Autodesk Inventor 2013. Teachers from the high school and Yogyakarta State University lecturers consistently evaluated the effectiveness of the tutorials as "very good" and two different groups of students rated them as "very good" and "good." Al-Hamad [4] determined that a hybrid approach of traditional classroom teaching along with independent student viewing of PowerPoint slides and digital video presentations was the most effective method in teaching CAD/ CAM /CNC tasks. The author explained that students thought this was the best approach (via survey) because the various modes of instruction made the learning process more enjoyable and consequently more effective.

The purpose of this research paper is to communicate the improvement of student performance in the modeling of parts and assemblies using Creo Parametric software when the author transitioned from traditional classroom instruction to the use of video recordings as the primary method of instruction.

Methods

The focus of Introduction to Engineering II at UofSC Aiken is on creating 3D models of parts and assemblies. The class begins with hand drawings using orthographic and isometric views. After students gain some spatial understanding using hand drawings, the author proceeds with instruction of the Creo parametric feature-based modeling program. This program is used in many industries to develop 3D renderings and 2D engineering drawings. In SP19, the author taught in a traditional manner, going step-by-step through the lessons in the Creo Parametric tutorial [1]. Several homework assignments were given to help students become proficient in the use of Creo commands and functions. In SP20, half (five of ten) of the Creo lessons were taught in a traditional classroom manner, while the other half were taught using recorded videos. In SP21, the number of Creo lessons taught via video recordings was increased to seven of ten. While the homework assignments varied somewhat over the three years, the type and complexity of objects in the assignments remained consistent.

A typical Introduction to Engineering II homework assignment requires the students to create two objects. The first object is created following a video recorded lesson following the steps of the tutorial [1]. This first activity helps students to learn the Creo commands and functions to create extrudes, revolves, and other features. The second object is created independently by the students to help reinforce their learning of the Creo tools and functions, and to check for their understanding.

The author created the video tutorials using the Yuja Software Capture program made available by the UofSC Aiken. For each lesson, several videos were created, each roughly 10 – 30 minutes long. Efforts were made to keep the video lengths in the 15 – 20-minute time range to help ensure students maintained their concentration throughout the presentation. However, shorter or longer videos were made based on the completion of certain tasks and convenient stopping points. In the videos, the author narrated his movements in the Creo program while displaying his computer screen – see Figure 1 below.

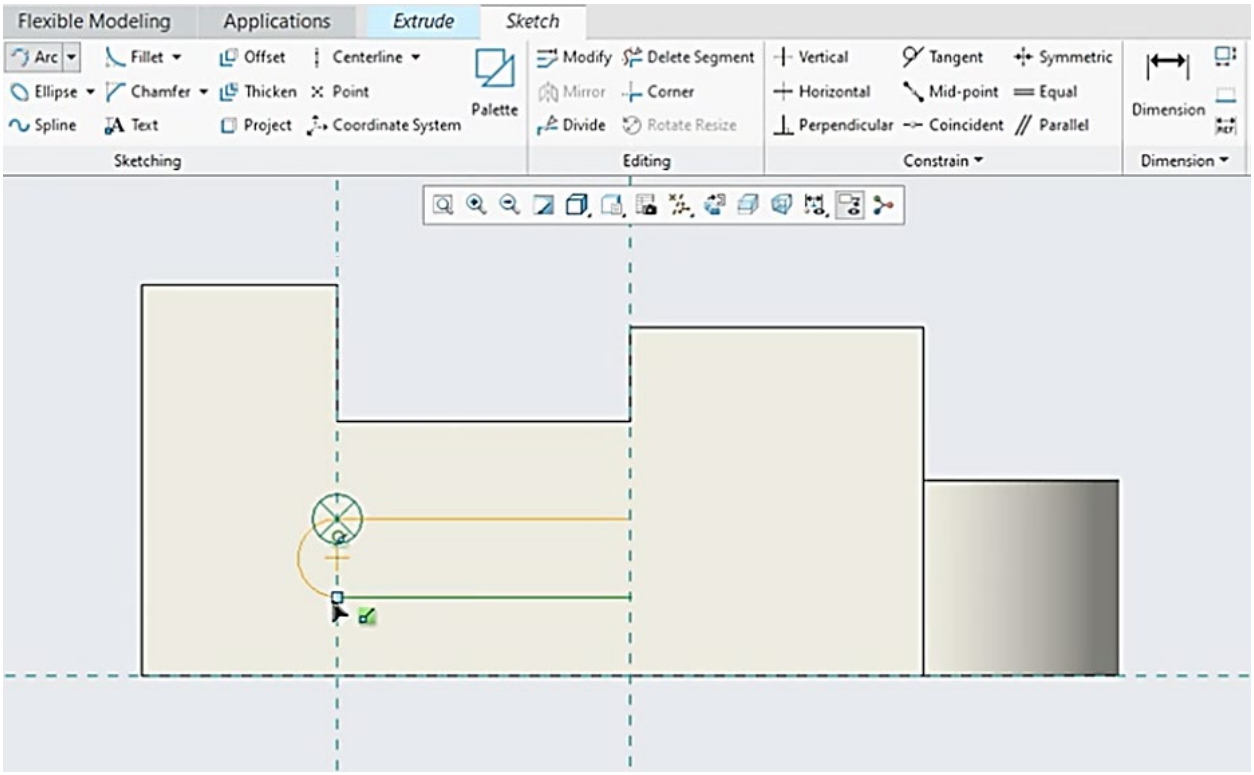

Figure 1. Example snapshot of a recorded video for ENCP A102.

For all homework assignments and exams, the assessment of students was focused on two areas:

1) ability to create an assigned object or assembly in Creo with shape and dimensions given.
2) ability to communicate an engineering design effectively with a 2D engineering drawing.

A midterm and final exam were given in each of the spring semesters, 2019 – 2021. The midterm exams tested students on the ability to model a single physical part of moderate complexity. On the final exam, students were required to model several parts and bring them together into an assembly. To ensure the integrity of the exams, the actual parts and assemblies were changed from one semester to another. However, careful attention was given to ensure a consistent level of complexity and difficulty for the exams from one year to the next. Figure 2 displays examples of the assemblies that students were tasked to create on the final exams from 2019 – 2021.

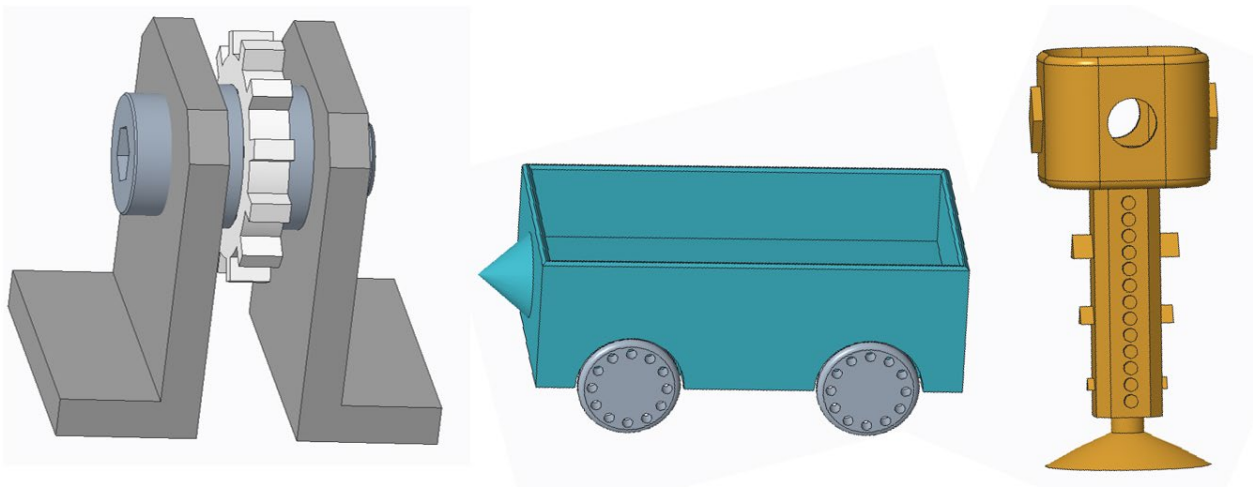

Figure 2. Assemblies required to be modeled by students on the ENCP A102 Final Exam for SP19, SP20, and SP21 (from left to right).

A final project was also consistently assigned in ENCP A102 from SP19 to SP21. For this project, students created a 3D model and a corresponding 2D drawing of an assembly of their choosing. Consistent with the assessment of homework and exams, the final project evaluated students in their ability to accurately represent their ideas in Creo (3D model and 2D drawing). However, this project also assessed students in some other areas. The evaluation rubric for this project included level of complexity of the object, accurate representation of the object, proper dimensioning, creativity, and clarity and accuracy of the drawings.

Results

Figure 3 shows that student performance on homework assignments and exams improved notably from SP19 - SP21.

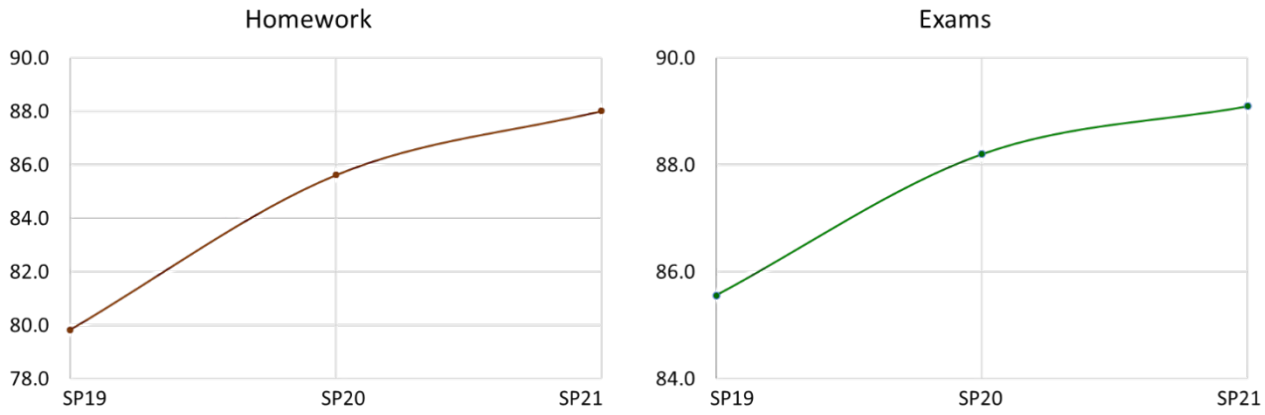

Figure 3. Average grades for ENCP A102 homework and exams for SP19 – SP21.

Figure 4 shows that student performance improved on the final project in each year from SP19 - SP 21. Since student performance improved in homework, exams, and the final project with each year, the overall course averages (also shown in Figure 4) also increased from SP19 – SP21.

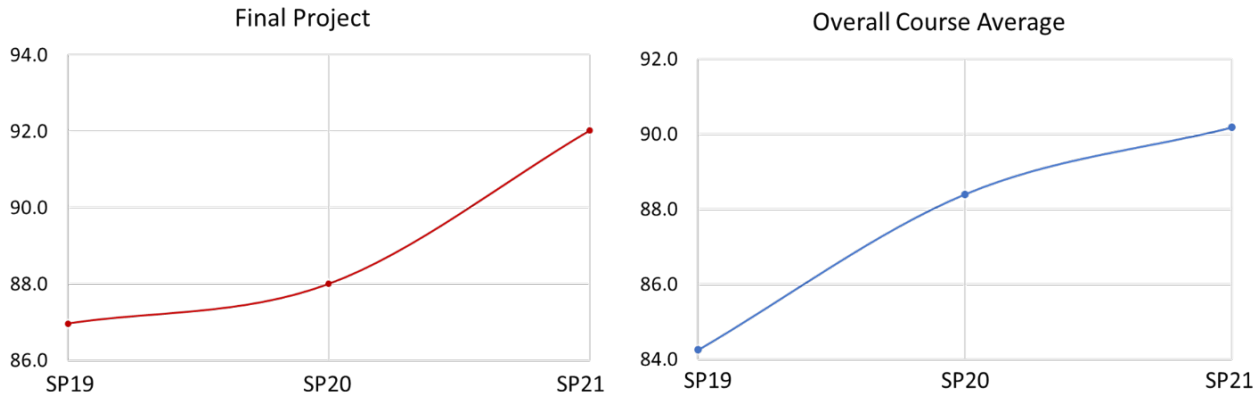

Figure 4. ENCP A102 averages for the final project and overall course grades for SP19 – SP21.

The author attributes the improvement in student performance across the board in ENCP A102 from SP19 – SP21 to the shift to the video recorded format. The reason for this attribution is that the course content, assignments, and assessments were all kept consistent throughout this period. While the homework varied somewhat, students were consistently required to model parts of similar complexity with each of the tools covered in the first ten chapters of Toogood [1].

Looking more closely at the overall performance of students from spring 2019 – 2021, the author determined the standard deviation (STD DEV) and range of the overall course averages for each semester. Table 1 below shows the overall class size for each spring semester (each year had two to three sections), the course averages, and associated ranges and standard deviations.

Semester	# Students	Highest Grade	Course Ave.	Lowest Grade	Range	STD DEV
SP19	34	96.4	84.3	63.3	33.1	8.12
SP20	32	98.4	86.1	72.1	26.3	6.43
SP21	27	98.6	90.2	77.7	20.9	5.81

Table 1. Number of students, course averages, and associated data for ENCP A102 from SP19 – SP21.

The data in Table 1 shows that both the highest and lowest grades increased with each year. This trend, along with the increase in course averages, indicates that the use of video tutorials was helpful to both high achievers and lower achievers. Additionally, the standard deviation and range of course averages went down noticeably with each year. This trend indicates that the video tutorials helped to narrow the gap between high achievers and lower achievers. Therefore, the use of videos seems to be most helpful to low achievers, which makes sense since they have more room for improvement in understanding and applying the material. High achievers tend to figure out the material and perform well regardless of the mode of instruction, but their performance did also improve with the use of the videos.

In addition to the positive trends in academic performance, students provided very positive feedback on the video tutorials in the UofSC Aiken Student Evaluations in Teaching (SETs). One of the questions asked of students was: "What were the most effective things the instructor did for this course?" In response to this question in SP21, 52% of the students answered with the recorded video tutorials. Specific student comments on the video instruction included:

- "I believe the videos were the most effective tool the instructor used…"
- "The recorded videos were extremely helpful for understanding the material."
- "I really liked the videos. If I missed something I was able to rewind and go back…"

Lessons Learned

For each ENCP A102 class, the author posted the videos within Blackboard via a web link. The videos have worked consistently with one exception – sometimes the videos failed to open at the start of class when many students were attempting to access the videos at that same time. Once this has occurred, the only reliable solution has been for students to log off and then back on to their classroom computer. A proactive solution to avoid the problem is to stagger the times that the students log in.

Some students have chosen to bring in a laptop or use their phone to watch the tutorial videos, while using a classroom computer to create their object. Other students have used a split-screen approach on one computer. Both approaches have proven effective. Students are asked to bring in headphones so that they can listen to the audio instruction independently from one another. When a student fails to bring in headphones, it slows down their progress and often leads them to request assistance. Therefore, the author reminds students ahead of time and usually has them bring in headphones to "test them out" at least one class period before they really need them.

The author considered creating videos for all ten of the lessons covered in the class. However, the decision was made to keep the first two lessons in a traditional teaching format for two reasons:

1) to help strengthen rapport between students and the instructor early in the semester, and
2) to ensure students understood the fundamentals of Creo before working independently.

The other lesson that has been maintained in a traditional approach is the first lesson covered after spring break. This course of action is recommended to help re-establish a connection with students after the break, and to help students get "back into the swing" of using Creo.

During the process of creating the videos and grading student homework, the author learned of some challenging aspects of Creo and some of the most common student errors. An example of this is establishing an axis of rotation for a "Revolve" feature. Students learn how to create a simpler "Extrude" feature first, which of course does not require an axis of rotation. Additionally, students are generally ready to start drawing as soon as they get into the Sketcher 2-D space and consequently often overlook establishing the axis of rotation for a "Revolve" feature. Another common area that some students struggle with are remembering how to accomplish all of the basic aspects of a good engineering drawing in Creo. The interface to create drawings in Creo is not as inherently intuitive as the feature creation interface. Therefore, if students are not patient and attentive to details, they miss things like showing hidden lines or

centerlines in the orthographic views. As a result of my awareness of these issues, I have emphasized these actions more and more with each class, which may have contributed to the improved performance from one academic year to the next.

Of note, the author has not tracked viewership of the videos via Blackboard to verify that students were indeed using the videos. However, students are given full class periods to watch the videos and the author has noted that almost all the students have consistently used the videos to complete the lessons. There have been a small number of students that have tried to do the assignments while only watching limited portions of the videos. Invariably, these students have struggled to complete assignments on time and/or performed relatively poorly, leaving out several details in the assignment. The author has noted a resistance by this small minority of students to get onboard with watching the videos even after noticeably struggling to complete the assignments effectively. These students typically have a strong desire to just get started on the "action" steps of completing the assignment and appear to have difficulty being patient with the process of learning from the videos.

Future Ideas

1) The author plans to continue with traditional classroom instruction for lessons one, two, and five with one adjustment – to create back-up videos for the material presented in class. This way, when a student misses a class or needs to review something that he or she didn't fully understand, they can watch the back-up video(s).

2) The author is considering having students do the video tutorials as homework prior to class and then doing the independent portions of the homework in the classroom. The benefits of this flipped classroom approach would be to have more interaction time with students during their portion of the homework that is less structured and may involve more questions. This approach would also help to move the class through the lessons and homework a little faster, thereby giving students more time to work on the final project at the end of the semester. The anticipated drawback of this approach is not being able to ensure students are fully watching the videos. This could be an issue given the relative immaturity of the students (freshman level). Furthermore, some students have limitations on their technological resources at home. In previous years, the author has encouraged students to download a free student version of the Creo program onto a personal computer. Most students have been able to do this, but others have had difficulty in doing so.

3) Since the use of a CAD program like Creo is characterized by mastering the processes and procedures of the program, the author plans to study research on mastery-based learning methods. The author will then look to compare different mastery-based methods to the use of video tutorials in ENCP A102 and see what adjustments could be made to further refine and improve the student learning experience.

4) Regarding the small minority of students that resist the full use of the video tutorials, the author plans to gain insights from colleagues and related research to investigate ways to motivate these students to get onboard with the video tutorial process.

5) Finally, it would be helpful to work with colleagues at a larger university that are teaching a class on Creo with a traditional classroom approach. One of the challenges in the instruction of a program like Creo is the need to help individual students "catch-up" when they miss a step. Depending on whether the instructor has teaching assistants, the rest of the class often must wait as the instructor helps these students. A transition to video tutorials in these larger classes would be a helpful indicator to see if a similar improvement in student performance was observed. The author hypothesizes that the use of video tutorials could prove to be even more helpful in these larger class settings.

Conclusion

When the pandemic disrupted the 2020 spring semester, the author sought to help students to cope with the situation by providing more flexibility in the mode of instruction. With this goal in mind, the author decided to record videos showing the steps of Creo Parametric tutorials for the Introduction to Engineering II class. This approach allowed students to access the videos at convenient times, to work independently at their own pace, and to rewind a video if they missed something the first time around. Since the creation of 3D objects and 2D drawings in Creo requires a lot of attention to detail, the use of video recordings (and the ability to rewind) has proven to be a reliable way to ensure students don't miss important details. Additionally, students have consistently provided feedback that they prefer the video tutorial approach over the more traditional classroom methods. The result of moving more instruction to the video format from 2019 – 2021 was that students performed progressively better in all areas (homework, exams, and final project). While some of the specific content of the homework and exams varied with each semester, the required learning outcomes and tools, and the level of complexity of assignments were maintained at a consistent level. The author therefore concludes that video tutorials are beneficial towards the improvement of student learning and performance in computer aided design classes, which is consistent with the previous research discussed.

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