Solid Edgecation: Development of Computer-Aided Design Curriculum for InSPIRESS

Ciarra Anjel Britt

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Innovative System Project for the Increased Recruitment of Emerging STEM Students (InSPIRESS) is a project under Experience for the Next Generation of Innovators through Networked Engineering Education and Research (ENGINEER) program that focuses on attracting high school students to engineering through collaborative projects with the University of Alabama in Huntsville. InSPIRESS students are tasked with creating and modeling a science instrument to serve as a payload on a spacecraft. Students are provided with Solid Edge computer-aided design (CAD) software where users can create models of solid objects. Learning Solid Edge presents to be a challenge for users without previous CAD experience. This is an obstacle due to the students only having one semester to learn the software, and successfully design and model their payload. The proposed solution of this problem was to create series of tutorials to teach basic modeling. The tutorials are delivered through video screen capture and documents. At the completion of the tutorials, students should be able to create basic shapes, render models, and assemble them into a final product. This allows the high school program more time to create and model their payload to a higher level of expertise, as well as an opportunity for a greater number of students to learn the software than before.
I. Background

A. InSPIRESS Program
Innovative System Project for the Increased Recruitment of Emerging STEM Students, InSPIRESS, is a project under the Experience for the Next Generation of Innovators through Networked Engineering Education and Research (ENGINEER) program run by Dr. P.J. Benfield and Dr. Matthew Turner at the University of Alabama in Huntsville. It provides high school students with the opportunity to create and develop a scientific payload to be placed on a spacecraft. The spacecraft is designed by senior-level engineering students in Integrated Product Design Teams, IPT, at the University of Alabama in Huntsville. IPT is under the ENGINEER program, also. High school students are given a mission overview of the IPT spacecraft. Some type of intergalactic science must be performed over the mission lifetime. Over the semester, the students decide what science they want to perform and design a scientific payload to complete their science objective. Each team is judged to ultimately decide which scientific payload will be placed on the IPT spacecraft.

B. Computer-aided Design
Computer-aided design, CAD, is the usage of computer software to create and model objects. CAD can be used to create two-dimensional drawings called sketches and three-dimensional objects called part models. It allows for the user to incorporate visual elements to a design. CAD models can be as general or specific as the user desires. Outside of technical drawings, its purpose is to illustrate an idea in pictures as opposed to words. For example, if a person is trying to sell a round, deep dish used for holding liquid or food, each buyer will develop a different mental image. If the person uses an identical description and includes the image located in Figure 1, the buyer automatically knows they are describing a bowl. Additionally, the buyer knows exactly what type of bowl. That is the power of CAD software. The scientific payloads created by students possess more complexity than a bowl, thus it is important that they are able to convey an accurate description of their model.

II. Assessment of InSPIRESS Students Computer-aided Design Abilities
The project files of nineteen teams from the InSPIRESS spring 2013 semester were compared for CAD improvement. Two project milestones were compared: Payload Status Review and Payload Concept Review. There is a six week gap in between the two milestones. Figures are required for each milestone, and the degree of complexity of each figure varies by team, Figure 2. Students are not required to use Solid Edge; however, it is highly encouraged.
A. Status of Models for Payload Status Review
Payload Status Review occurred during the week of February 25, 2013 to March 1, 2013. By this point, teams were expected to have two scientific payload concepts with a general model of each concept. CAD models are not expected; however, a general drawing should be possible. The comparison of 19 teams concluded that two teams (11%) had utilized Solid Edge to create their payload, fourteen teams (74%) utilized other methods to create drawings, and the remaining three teams (16%) did not have a drawing. Of the 14 teams that utilized other methods to create drawings, five teams (36%) scanned hand-drawn pictures, seven teams (50%) took photographs of their drawing on a marker board or piece of paper, one team (7%) used shapes found in Microsoft toolbars, and one team (7%) used pictures from the internet.

B. Status of Models for Payload Concept Review
Payload Concept Review occurred during the week of April 8, 2013 to April 12, 2013. By this point, teams should have a nearly finished project. CAD models, if being used, should be near completion. Any visuals that are not CAD models should be drawn in a neat, professional manner. The comparison of 19 teams concluded that eight teams (42%) had utilized Solid Edge to create their payload models, ten teams (53%) utilized other methods to create drawing, and only one team (5%) did not have a drawing. Of the ten teams that utilized other methods to create drawings, two teams (20%) scanned hand-drawn pictures, four teams (40%) took photographs of their drawing on a marker board or piece of paper, three teams (30%) used shapes found in Microsoft toolbars, and one team (10%) used pictures from the internet.

C. Overall Model Trends
During the six week gap, only six more teams decided to use Solid Edge to model their scientific payload bringing total usage up to 8/19 teams. Figure 3 and Figure 4 illustrate the usage of other methods to create visuals. Photographs of a marker board diagram were the most common visual. Marker boards are in almost every classroom, thus it is fitting that students utilize them to create drawings. Additionally, marker boards allow group collaboration for design, and for mistakes to easily be erased. An interesting observation in model creation is the lack of a trend after photographs of a marker board. When the pie charts on the right side of Figure 3 and Figure 4 are compared, there is no defined behavior in the increase or decrease in different methods to create visuals. The results are as randomly distributed as before.

![Method of Visual Creation at 1st Milestone](image-url)

**Figure 3.** Distribution of methods used to create diagrams during Payload Status Review of February 25 to March 1.
D. Decision of Tutorial Topics
The original goal of Solid Edgecation was to refine the CAD skills of InSPIRESS students; however, that goal had to be adjusted after comparing semester improvement. It was assumed that most students would take advantage of Solid Edge software. Figure 4 clearly shows this assumption to be false. Instead of refining the skills of students, Solid Edgecation teaches students how to create visual models while showing the advantages of using the software for the competition. Since majority of students do not have any experience with the software, the tutorial topics had to start off with basic tasks and increase in complexity with each new tutorial. The final topics to be covered are the importance of computer-aided design, an introduction to Solid Edge, two-dimensional sketching, three-dimensional modeling, combining parts into an assembly, and rendering models.

III. Method of Delivery for Tutorials
The primary purpose of creating tutorials was to provide a step-by-step process of creating and editing models for InSPIRESS students to follow. The secondary purpose of the tutorials is to illustrate the ease of use for Solid Edge. This should motivate students to try to use the software for their projects.

A. Video Tutorials
Video tutorials provide a visual and audio platform for InSPIRESS students to follow. Each video tutorial opens with a summary of what tasks the student will be observing and performing. This provides the opportunity for students to know which videos to watch for features they do not know how to use. Additionally, the video introduction states what tasks should be easier to perform after completing a tutorial, providing a platform for self-assessment. If the task is not easier after tutorial completion, or they continue to have problems with certain features, the student knows exactly which video to watch again.

Video tutorials are recorded using ActivePresenter by Atomi Systems. The software allows for the screen of a computer to be captured in a video. The videos are recorded with the full motion recording option. This allows for pausing, recorded audio, tracking cursor movement, hotkeys, and much more. Audio for the tutorials was recording using a Ball Snowball microphone and Windows' built-in sound recorder. Audio and
video were recorded separately due to the microphone picking up surrounding noises, such as mouse movements on the desk and keyboard clicks. The video and audio files were combined and edited in ActivePresenter to form the final version of each tutorial, Figure 5.

![Figure 5. Screenshot of ActivePresenter editing interface](image)

**B. Document Tutorials**
Document tutorials mirror the video tutorials. Instead of having to watch the full length video, students are able to follow tutorials through screen captures. As with the video tutorials, each document begins with a summary of what tasks the student will be observing and performing.

**IV. Topics Discussed**

**A. Importance of CAD**
“Importance of CAD” is not a tutorial; it is a PowerPoint document. The main objective of the document is to motivate students to use the software. It serves as an introduction to computer-aided design for students who are unfamiliar with CAD. Additionally, it highlights the benefits of using models instead of relying solely on descriptions, and the power of 3D modeling. No modeling techniques are taught from the document.

**B. Tutorial One: Getting Familiar with Solid Edge**
The main objective of “Getting Familiar with Solid Edge” is for students to explore the software on their own and attempt to try out features without guidance. Its purpose is to familiarize the student with the Solid Edge interface before they begin detail-specific tutorials. This tutorial introduces software layout, different toolbars, and basic features of Solid Edge. The video walks the user through the tab layout of the software to illustrate its similarity to other programs, such as Microsoft Word. The document is similar to the video
and has a screenshot of each tab with what that tab does to a sketch. The main focus of both tutorials is the HOME tab. This tab houses majority of the Solid Edge functions InSPIRESS students will use for the duration of their project. No modeling techniques are taught from the video or document.

C. Tutorial Two: 2D Sketching and 3D Modeling
The main objective of “2D Sketching and 3D Modeling” is to illustrate the importance of creating simple two-dimensional sketches and leaving complex surface features to be done once the model becomes three-dimensional. The tutorial begins with a model that resembles a cup. It discusses how the model will be recreated using two different methods: 1) a complex 2D sketch with minimal 3D modeling features and 2) a simple 2D sketch which utilizes 3D modeling features to add complexity. At the conclusion of the tutorial, the students have created an identical cup model in two completely different ways. The main focus of the tutorial is to illustrate the importance of creating simple models. The secondary focus is to illustrate how models can be created in a myriad of ways, and the execution of creation is dependent on the user and their preferences. Sketching functions used in the tutorial: lines, circles, dimensions, IntelliSketch, trimming lines, and edge fillets. Solid modeling functions used in the tutorial: revolve, extrude, draft angles, and thin wall.

D. Tutorial Three: Combining Parts into an Assembly
The main objective of “Combining Parts into an Assembly” is to illustrate how to combine separate part files into an assembly. The assembled product is a simplified Schylling LED Head Lamp. Before students can begin the tutorial, they must build the parts required for assembly. Dimensions for parts are supplied; however, there is no step-by-step guidance of how to complete the parts. This is to challenge the student to practice their modeling skills without any assistance. The tutorial guides the student on how to assemble different components together. The secondary focus of the tutorial is the importance of constraining parts for model accuracy. At the conclusion of the tutorial, students have completely assembled the simplified Schylling LED Head Lamp, and have been informed of major types of Solid Edge constraints.

E. Tutorial Four: Rendering Models
The main objective of the tutorial is to illustrate how to render assemblies. This tutorial is a continuation of “Combining Parts into an Assembly.” The main focus of the tutorial is to highlight the difference between default Solid Edge models, and models that are realistic and aesthetically pleasing. At the conclusion of the tutorial, students have performed a complete render an assembly.

V. Conclusion and Future Recommendations
The created tutorials will be uploaded to the InSPIRESS website (www.inspiress.org) during summer 2013. The next round of InSPIRESS student will have access to the tutorials. In theory, this should lead to an increase of Solid Edge usage in projects. Furthermore, the usage of Solid Edge should be to a higher level of expertise than previous models. The successfulness of Solid Edge education will be based upon these two theories holding true.

If the usage of Solid Edge does not increase, other avenues of increasing student usage of the software will need to be explored. One idea was to have an incentive for using Solid Edge that is not officially part of the InSPIRESS competition, such as a best CAD award. The award would recognize the best looking model at the InSPIRESS open house held each semester.
A recommendation for expanding Solid Edgescation is for students to design a science instrument as they complete tutorials. For instance, instead of assembling a flashlight, they would assemble some instrument previously flown on a spacecraft. Other recommendations are to include frequently asked questions documents as mini tutorials. Questions that will be answered are supplied by students and teachers at the end of the InSPIRESS semester. Due to the semester ending near the project deadline, topics and creation of the mini tutorials are still in progress. These will also be available on the InSPIRESS website.

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