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Toy Creation That Taught So Much More

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Abstract
The creation of the Star Wars Rogue One movie K-2SO droid was a group project application result of designing and 3D printing culminating knowledge obtained during one of the Applied Engineering, Safety, and Technology department's courses. The goal was to achieve a moveable and realistic, yet smaller, duplicate of the droid that was portrayed in the movie. By using the skills taught in the Computer-Aided Engineering Drawing class in the Fall 2020 year, we were able to successfully reverse engineer, sketch, design, and 3D print the model. To create the finished product, the MakerBot Replicator and Replicator 2X 3D printers and SolidWorks software were utilized to design and print the model. By dividing the model into different parts and using ball joints to connect them, the figure was then able to move its limbs. This project taught various important skills such as abstract and critical thinking, problem-solving, the importance of creativity, working on a team, prototyping, and setting goals/timeline benchmarks.

The plan for designing this model was to create a figure that would be able to stand, have moveable joints, and be balanced in different types of positions. In designing K-2SO, the importance of dimensioning parts correctly was essential because, for example, if the dimensions for attaching ball joints were wrong or if the balance of the model was uneven on one side due to one part being larger than the other, the figure would be unbalanced. The project requirements included having at least six moveable parts and the overall model under six inches in height. These requirements were met by creating parts that will behave as knee, elbow, ankle, and shoulder joint types, allowing the figure to move and be manipulated in different positions. This allowed the model to move in different positions without coming apart.

Brainstorming

As a team, we had to decide how to best start the project and move from sketches, to models, to drawings along with deciding what type of filament to use on our final project. When it came to 3D printer filaments, both PLA (polylactic acid) and ABS (acrylonitrile butadiene styrene) were applied due to their specific material properties. Filaments are melted by the printer and then extruded into different layers, slowly building up the specifically designed piece. Since ABS is the stronger of the two filament types, it was applied in the areas where strength mattered the most: feet, legs, torso, head, and some of the ball joints. However, when detail was more essential we used PLA: arms, hands, and thighs.

Drafting/Design

To design K-2SO, as a group, we needed to figure out what would be the best way to make sure everything would align and connect after 3D printing while assuring the overall appearance would look proportionally correct. By implementing the methods of reverse engineering through obtained and resized photos of K-2SO, we were able to make our final design look proportionally correct while adhering to the size limits criteria. By creating sketches based off of the resized photos we obtained, we were able to create dimensions and figure out how to properly size everything and then create 3D models based off of those sketches. Then, we went about dividing our work and assigned who was supposed to design what. When it came to designing the joints where the pieces would fit together, this took a lot of trial-and-error and collaboration before we reached final designs. During the processes of prototyping, testing, and re-designing, team member collaboration was vital to the completion of the project. As part of the process to ensure that the figure could be assembled properly, two-piece joint prototypes were designed with specific dimensional tolerances allowing them to be joined together. To meet the requirements for our project, we needed to show skills we had learned during our class Computer-Aided Engineering Drafting, and possibly explore creative and new ways for designing parts. Throughout the entire semester, the class taught us many skills that we needed to utilize for the final project to show that we could retain and implement information and skills. Although several simple drafting skills were applied such as drawing lines, circles, and extruding, it was also necessary to use more complex skills and tools including lofting, revolved cuts, sketching on different planes, and others to provide the opportunity to create more detail within our final product. After each part had been designed and discussed with the group, we were ready to move onto the printing phase of our project.

Printing and Redesign

After the 3D models were completed in SolidWorks, the software that allows the designer to 3D model objects, the files were converted by a “slicing” software which allows the 3D printer to understand the design and create the printed part one layer at a time. These are the preliminary steps of the 3D printing process. It took a few tries to determine the correct amount of infill and printer speed to produce the best result. Infill is the amount of filament used to construct the figure. For example, 100 percent infill would mean each piece of the figure is solid; 30 percent infill means only 30 percent of the figure is solid. 3D printer filament is plastic in the form of a wire. Printer speed ranges from 40 mm/s to 70 mm/s, which is how fast the printer head moves while printing. Slower speed generally produces higher quality. Once the correct settings were determined, the printing could begin.

Each student worked individually for the most part to 3D print their designed pieces, collaboration was needed to ensure each piece would fit with those created by the other team members. As stated above, ball joints were used to connect the arms and legs to the torso of the body. A standard size was agreed upon for each joint so each design could be created accordingly. While most parts were printed successfully on the first or second try, many attempts were made to perfect the fit of the ball joints. The ball joints were printed separately to save filament and then edited accordingly so they would be correct on each part of the figure. This ensured the final product would fit perfectly.

One occurrence that shocked us was the amount of time it took to print some of the parts - it was astounding. The figure's torso was the longest print time for one part; it took roughly 6 hours. Our biggest challenge faced was the size of some of the pieces. Since the overall length of the assembled figure could not exceed 6 inches, some of our pieces were extremely small. The original design for the torso included two antennas protruding from the back of the shoulders, however, these antennas were so small it was hard for the printer to produce them accurately. Similarly, the figure's fingers were about one-sixteenth of an inch wide, and they were extremely hard to not only design but also successfully print. This challenge was only understood in the printing phase; when designing parts in the SolidWorks software, the designer can zoom in and out that it is hard to grasp a part's true size. Another challenge faced during this project was how to orientate some of the pieces for the best output solution. Orientation is how the object is placed on the printing table. The upper arm had a sphere protruding from one side of it, making it a challenging feature to print, and required many tries to find the correct orientation. Most other pieces, however, had to be oriented correctly for the features to be more distinct, and so the print time was not as long. After each print had been completed and we had our final project complete, we took the final models that were made and created drawings from them. The purpose of the drawings is to show what dimensions were used for the final parts so that the parts could be replicated if needed.

Conclusion

This class and final project taught our team so much about engineering drawing and CAD, problem-solving, and real-life applications of the work. Collaboration was essential to complete the project on time and make it functional according to the rubric criteria. Setting benchmarks allowed us to create a realistic timeline that contains goals and workarounds if there were to be any issues that allowed us to complete our project on time. Proper division of labor allowed all members to work fairly and evenly. Reverse engineering and proper scaling allowed us to properly dimension and recreate our iteration of K-2SO.

Recommended Citation
Kiesel, R. G., Wogari, E. A., & Tarter, L. H. (2021). Toy creation that taught so much more. *Made in Millersville Journal*, 2021. Retrieved from https://www.mimjournal.com/paper-84