Trifling with Rifle Badges

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https://youtu.be/s9zqadvjVO0

Abstract

This year, a group of Diamond Bar High School students was inspired to design and create a device that would assist workers with disabilities assembling "Rifle Expert" medals (*see Figures 1-3*). With the help of a faculty coach, these students partnered with the nonprofit organization FRW dba Industrial Support Systems to improve the assembly process by designing assistive devices and implementing technology in order to improve employees' productivity and efficiency. Students noticed that the worker's approach to fastening the clasp of the badge to the marksmanship plate was inefficient. By researching possible solutions that would expedite the assembly process at Industrial Support System, students designed devices that provide easier handling that reduced discomfort, and reduced assembly time by 41%. Through this project, the team was able to accommodate individuals with disabilities and better understand the difficulties that others face through interaction and communication.

Figure 1- Completed Medals

Figure 2- Packaged Medals

Figure 3- O-ring Attachment

I. Statement of Problem

In order to maximize the full employment potential of workers with disabilities, FRW holds contracts with local companies that range in a variety of work from labeling to assembling. Because their work environment is so dynamic, it takes a great deal of time for workers to undergo training and adjust to their new job at hand. At the time that students were working with FRW, the marksmanship badge was a new project, and workers were having trouble adjusting to the manual assembly process. In order to combat this issue, the students worked to lower the learning curve of assembling the badges so that when another order of badges arrives, workers are able to adapt quickly and produce products efficiently. Each stage of the assembly process presented several problems for employees—the biggest problem being fastening a 4-millimeter wide O-ring between the clasp of the badge and the marksmanship plate. Due to limited dexterity and motor skills, workers with disabilities required more training and took longer to meet the standards of quality control. With these concerns in mind, students created several devices that increased efficiency and comfort so the workers could seamlessly adjust to the new job at hand.

II. Background

FRW doing business as Industrial Support Systems (ISS) is a non-profit organization that has been employing adults with disabilities for over 50 years. When it was established in 1964, FRW's main goal was to provide programs and activities for students with disabilities across the Fontana School District, giving individuals with disabilities a chance at employment while assisting them throughout the experience. Despite separating from the school district a year later, Industrial Support Systems has continued to incorporate the same ideals as when it was founded, currently serving hundreds of workers with disabilities. Partnering with AbilityOne has provided work opportunities in the form of packaging and assembling military badges for the federal government. The SourceAmerica Design Challenge encourages student participants to create devices or inventions that assist workers with disabilities that maximize efficiency and comfort. Students have addressed key bottlenecks within the military badge assembly process by arranging the workers into workstations and developing individual solutions. In doing so, the team is able to consider more holistic approaches to increase efficiency, leading to increased ease of access to workers and a reduction of unemployment in the community.

Figure 4- FRW Plaque

III. Rationale

After gathering quantitative and qualitative data, students came to realize that the workers struggled the most on the second step in the assembly process: connecting the two parts of the metal badge with two O-rings. Because these actions required fine motor skills and steady hands to thread the O-ring while also aligning the two medal pieces, the team decided to create a jig that will allow for easy alignment and easier handling.

For the remaining stations, the students observed the tasks that were more time-consuming and created devices that can simplify the job. For the label placing station, the students noticed that the workers had to pick up the heavy roll every time and occasionally struggled to separate the labels from the roll. This was easily remedied by making a label dispenser that enables single handed use, freeing workers up for multitasking. Our team also designed and created a label aligner to improve the product's visual appearance by allowing every box's label placement to be uniform.

IV. Development

In order to create devices that were easy to use and implement for SMEs with limited fine motor skills and dexterity, each invention went through several prototypes before eventually settling on the final design, factoring in overall cost and resulting learning curve.

Medal Alignment Jig

The devices that aided the process at station two required the most brainstorming and prototyping, as it involved small pieces with tight tolerances. The team first thought of fixing the label piece onto a tack board so that the workers would only need to handle one piece at a time. Although the idea was simple, it was quickly discarded as it made threading the O-ring through the holes difficult because the tack board would often cover up the hole. The next idea was to create a one-piece jig that holds both medal pieces. This prototype was made out of clay and tested as a proof of concept (*see Figure 5*). We chose to use clay because it was an easily accessible and rather cheap molding substance that would not take much time to process. Despite these advantages, we quickly found issues with difficulties in manipulating and controlling the clay molds into the desired shape. To create quick and accurate prototypes, the team eventually settled on using 3D printing to bring the inventions to life (*see Figure 6*). The team's first 3D printed design used two inverted cases that would each hold one part. This jig allowed the workers to have a more ergonomic hold on the pieces and align the holes with ease. This design was then further improved by combining the two pieces into one with the holes already pre-aligned. The button of the jig also has an opening at the back allowing the workers to easily remove the completed medal piece by pushing from the back. At the end of the design process, the team decided to add one more enhancement to keep the rings steady when the workers attempted to close the rings. This was achieved by creating two small indents at the back that would help align the rings.

Figure 5- Medal Alignment Jig (Clay)

Figure 6- Medal Alignment Jig (PLA)

Medal Alignment Holder

After visiting the facility for the second time for feedback, one of the workers complained about their difficulties of holding the jig and pliers simultaneously. They requested that the team design a device that keeps the alignment jig steady and planted so that they could have the mobility of both hands. The team tackled this problem by designing a holder that utilizes a container for structural integrity and convenience (*see Figure 7*). The cover was designed for the alignment piece to slide in allowing the workers to focus on the crimping process with both hands.

Figure 7- Medal Alignment Holder

O-ring Opener

In the process of assembling the rifle expert badge, workers occasionally had to widen the O-rings to accommodate the holes. Their method to accomplish this was inefficient and difficult as it required the workers to wield a plier in each hand. The students tackled this problem by looking for possible alternatives to twisting the rings. The team first thought of positioning the O-ring on top of a conical figure, then applying pressure so that the ring would widen itself according to the shape of the cone (*see Figure 8*). After the students 3D printed the model, the team came to realize that the PLA plastic was not strong enough to withstand the pressure of widening the metallic O-rings. In the next iteration, the team thought of fastening the O-ring on the edges of two separate platforms and driving a wedge between the two (*see Figure 9*). The students affixed a pin at the ends of both platforms so that the O-ring could slide into the pins. Then, a makeshift wooden wedge was created to be driven into the two platforms. Although the wedge provides a mechanical advantage, the team quickly discarded the idea because the jig itself did not decrease the overall time of assembly. Eventually, the students settled on utilizing snap-ring pliers accompanied by a rig that holds everything in place allowing one-handed usage (*see Figure 10*). The first prototype that held the plier upright was 3D printed and tested. However, due to the small sizes of the O-rings, the rings could easily fall off the ends and get lost on the table. To combat this problem, a plate was created under the ends of the plier to catch potential rings that may fall off during the widening process. Multiple 3D printed prototypes were made with small tweaks to obtain better tolerances so that each part fits in seamlessly.

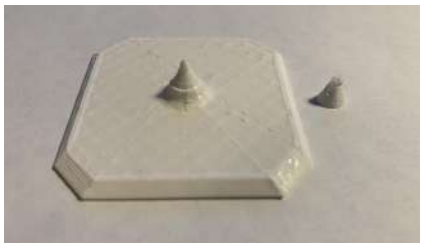

Figure 8- O-Ring Opener (1.0) *Figure 9- O-Ring Opener (2.0)* *Figure 10- O-Ring Opener (3.0)*

Label Aligner

At station three, the students noticed that the label placement on many of the boxes was crooked and off-centered, making the finished product look rushed. To tackle this problem, the team created an item intended to align the label and reduce the time it took to apply the labels. The first design that was 3D printed was bulky and only supported one box at a certain orientation to properly place the label. While this prototype wasn't optimal, it proved the concept was achievable and therefore allowed the team to create better versions. The next prototype was slimmer and allowed the box to be inserted at two different corners to centralize the label. The last and final design took advantage of the simpler box orientation to create a jig that allowed four boxes to be inserted at once and easy alignment of the labels (*see Figure 12*).

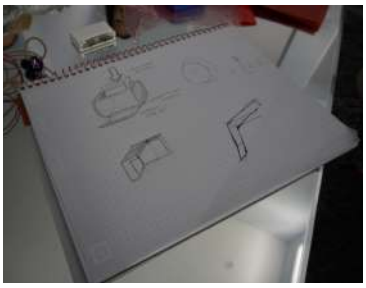

Figure 11- Station 4 Early Designs *Figure 12- Label Aligner*

V. Final Design

The final design includes devices for two of the four stations that the workers work on. The students' first invention aims to improve the efficiency and usability of the second station, which requires the workers to stretch open O-rings to attach the two complementing medal pieces together to create the rifle expert badge (*see Figure 14*). To help the workers thread the O-ring through the holes, the team created a rig to hold the two medal pieces together that lines up the holes (*see Figure 13*). The rig also has a hole at the bottom that allows the workers to push the pieces out with minimal effort. In order to make the process even simpler for the workers, a second invention was made to simplify the process of widening the O-rings. This design allows the workers to use a single hand to accurately widen the O-ring to a designated width. This is achieved by a jig that holds a pair of snap ring pliers upright and a stopper that prevents the pliers from opening too wide. Directly underneath the pliers is also a built-in white plate that will allow the workers to see and easily pick up the O-rings if they fall off the ends. These two inventions work hand in hand to improve efficiency while also simplifying the overall process.

Figure 13- Medal in Jig

Figure 14- O-Ring Opener

For station three, where workers are assigned with peeling labels from a roll and placing the labels in the middle of the box that holds the finished medals, the students created two tools to aid the workers for simplicity and overall satisfaction. The first tool borrows the general concept of label dispensers to create a modified version that fits the standards at the facility. This device is capable of omitting labels piece by piece by tugging on the roll that is enclosed by a specifically designed chamber (*see Figure 15*). With this design, workers can peel off the labels with one hand for easy accessibility. The second design for this station complements the label dispenser as it helps the workers align the label placement on the boxes for uniformity. Not only does this design help the workers accurately place the labels on the center of the box, but it also serves the purpose of keeping all boxes identical providing visual satisfaction for the workers. The device is shaped in a "plus" shaped design that allows the workers to insert the four boxes into the four corners to help align the labels. To keep the label placement uniform, the device allows the box to be inserted on either of the long sides without requiring a specific orientation, making it easy for the workers to adapt to.

VI. Assembly Process

In order to help workers adapt to the new tools, each device was carefully designed to minimize the number of parts required and the complexity of the setup. In order to set up the jig for station two, the plier is inserted into the designated hole with the ends facing towards the white plate underneath. The stopper is then placed on the backside of the plier where the two holes are. To make this process easier, the stopper was designed to fit in both directions. The rig that holds the medal pieces in place also has an easy assembly process. First, the worker places the label piece into the deeper slot with the pins facing up and the rings facing outward from the jig. Next, the body piece goes on top, with the flat side down and rings aligned with the label piece. These assembly steps for the devices for station two require no longer than 10 seconds.

Figure 15- Label Dispenser and Aligner

The two devices for station three (labeling) also require little setup. The label dispenser is composed of two parts: the main body that houses the roll of labels and the cap with a built-in gauge that allows the user to see the remaining label without removing the cover. First, the cover is removed and the label roll is placed in so that the loose end comes out of the top left. The loose end is then inserted into the crevice so that the device can work properly. After that, the cover is placed back over with the part sticking out covering the complementing piece on the main housing to provide support. The label aligner requires no setup and is designed in a way that allows the user to insert the box in any direction.

VII. Cost Analysis

Materials for Ring Openers	**Cost**	**Vendor**
Snap-Ring Pliers Set	$14.98	Lowe's
31g Soultech White PLA (body)	$0.47	Amazon
1g Soultech White PLA (stopper)	$0.01	Amazon
Total	**$15.46**	

Materials for Medal Aligners	**Cost**	**Vendor**
5g Soultech White PLA	$0.08	Amazon
Total	**$0.08**	

Materials for Label Dispenser	**Cost**	**Vendor**
119g Soultech White PLA (body)	$1.79	Amazon
31g Soultech White PLA (lid)	$0.46	Amazon
3g Soultech White PLA (stabilizer)	$0.04	Amazon
Total	**$2.29**	

Materials for Label Aligner	**Cost**	**Vendor**
10g Soultech White PLA	$0.16	Amazon
Total	**$0.16**	

VIII. Testing Procedure and Results

The team went to FRW Industrial Support System in January for the second time to introduce the product solution. During the testing procedure, students introduced the jigs to the SMEs and demonstrated how the devices worked. The students explained how to maneuver the devices with step-by-step instructions. The SME, Charlie, was introduced to the Medal Aligners. He was able to correctly place the clasp into the deeper slot with the pins facing up and the rings facing outward from the jig. Then, Charlie incorrectly placed the body piece upside down. However, he quickly noticed that the plate did not snugly fit and rotated the body piece onto the correct side. With the rings perfectly aligned, Charlie was able to dedicate all of his concentration on fastening the O-rings which significantly reduced the assembly time by 47%. Previously, Charlie applied a firm pressure around the badges to keep the ring openings aligned. This left his thumb aching for applying too much stress on his muscles for over a long period of time. However, with the help of the medal aligner, Charlie is now able to assemble the badges with comfort and efficiency.

Process	Time without Device	Time with Device	Overall Improvement
Badge Assembly	2:36	1:22	47%

Lean Manufacturing Setup

While the student team was on site collecting test results, they were told that the FRW just received another order from the Department of Defense to make about 200,000 pieces, and the parts shall be sent to the facility sometime in February. The student team captain Ryan Lou was invited to the Finalist Event in Washington D.C. in April 2019, and learned the lean manufacturing concept at the first day training. *(See Figure 16).* We would like to verify how the lean manufacturing cell works compared to batch production when the new order comes in. Station 1 has one worker, who will deliver finished parts to station 2A or 2B, a bottleneck process, then station 3 places the labels on the box, and station 4 receives parts from 2A/2B and 3 to package the product according to the requirement. Orange color post-it labels are placed between stations as “Kanban” to allow PULL operations, instead of the PUSH batch process. The yellow arrows are

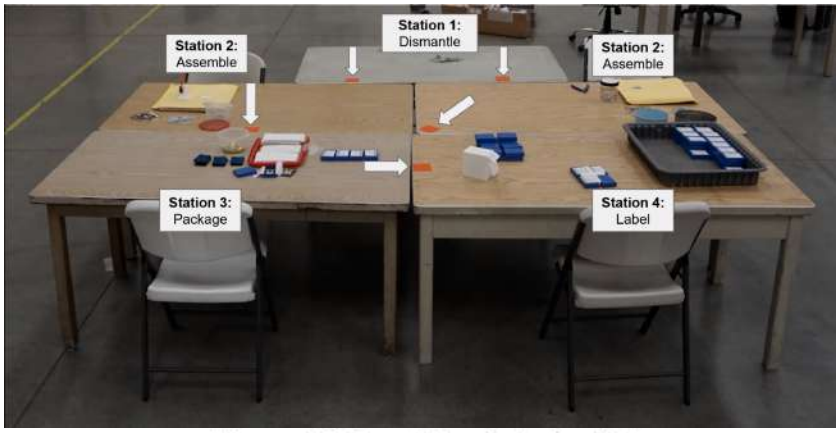

Figure 16- Lean Manufacturing Setup

showing the pull directions and pointing to the Kanbans.

IX. Community Impact

Designing technology that can further provide assistance to workers with disabilities truly impacted FRW Support System Industry. Silvia Anderson, CEO of FRW Support System Industry, commented on how the team has "taken into consideration those with different levels of skill, and [gave] someone that may not have the manual dexterity the opportunity to do this job." With the help of the Medal Aligners, Silva Anderson now has confidence to employ more workers with disabilities to assemble the marksmanship badges, providing increased employment opportunities in the coming years. Furthermore, the device has empowered Charlie to assemble the marksmanship badges with more comfort and efficiency. No longer experiencing pain from applying too much stress on his muscles when assembling the badges, Charlie feels that the devices improved work production. FRW Industry Support System is always looking for improvements, and with these devices, it's a start to a successful future.

X. Conclusion

Students expanded their design, engineering, and communication skills throughout the development of these assistive devices. They learned time management and organization in the documentation process. In the end, the solutions that the students developed were a blend of simplicity and ingenuity, built upon core concepts that can be applied to other items as well as to other industries. Overall, the team succeeds in engineering assistive devices that will not only impact workers at that specific company but also has the potential to impact employees on an international scale.

References

Anderson, Sylvia. FRW Industrial Support System. Personal Interview. 21 Jan 2020.

Hess, Kenneth. "The Engineering Design Process." Broadcom Foundation, 10 Jan,2020, www.sciencebuddies.org/science-fair-projects/engineering-design-process/engineering-design-process-steps.

Porter, Paul. "Achieve Independence Through Employment." FRW Industries INC, Fontana Resources, 2011, www.industrial-support.org/about/.

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