Final Evaluations and Analysis
Fine Motor Skills Group
Product Design Capstone Autumn 2019

Samantha Jones, Gian Carlo Valli, Doug Hoffmeister,
Michael Lloyd, Brendan Mountain

Summary

The Fine Motor Skills Product Design Capstone Team has been working the previous two semesters to develop a medicine delivery system for a student with a deficiency in fine motor skills. The team has iterated through many rounds of prototypes while gaining feedback from the user throughout the process. Three different studies were conducted by the team to gain insight on functionality and evaluate the final prototype. The team gathered results from the testing and identified both positive and negative features/functions of the final prototype. Additionally, next steps were identified based on both feedback from the user and results from product testing.

Product Specifications to Be Evaluated

The team's primary goal was to develop a product that could be used daily by Jen to help ease the process of taking medicine. As such, one of the primary product specifications that the team desired to meet was to have the product be usable by Jen. It was important that she could use the product when her finger dexterity was both high and low. The team was in constant communication with Jen throughout the design process, and upon the conclusion of prototyping, it was important to allow Jen to provide her feedback of the product's successes and failures.

Along with Jen's qualitative opinions of the product, the team wanted to understand the product's time and effort savings for Jen. From the initial research, the team understood that using syringes every day was a difficult challenge for Jen. By comparing the energy expenditure and time saved by using the product, the team was able to quantitatively evaluate the impact it could have on Jen's day to day life. Since the purpose of the product is to be a medical device, precision was also a key factor to ensure user's safety while using the product. The team chose to evaluate the delivery capabilities of the product. The team chose to measure the repeatability of delivering 3 mL of medicine with each dosage.

Evaluations Set-Ups

Three different evaluations were conducted by the team in order to evaluate the above product specifications. Test procedures were laid out in the team's *Evaluation Proposal*, however, some changes were required to respect the limited time of Jen and provide more useful data with a short evaluation time. The changes to the test are outlined as follows.

For the 3 mL Delivery Repeatability test, Jen was no longer a participant. Initially, the team saw value to ensure she could provide results consistent with other users. The team recognized the heavy inconsistency in all participants due to leaking in the product. The team did not want to have Jen spill liquid on herself while trying to use the product, and it was apparent that the test would not pass with or without her results. The time with Jen was used elsewhere in testing. Additionally, the team used a 1 to 1 honey-water mixture in order to simulate the medicine. Lastly, only one prototype was used for the evaluations, as the others had more serious leak issues.

For the Usage Time vs Syringe Test, the team reduced the number of samples from a minimum of 5 to 3 samples. This was not planned, but the first three tests resulted in less than 1 second of variation, and it was apparent more tests were not required. Once again, the team saw this as an opportunity to respect Jen's time. Additionally the post test questions were changed from the initial proposal. Prior to testing, the team recognized that with the daily variations in Jen's dexterity, it was not as useful to rank the relative ease of the product, but rather understand how the ease would compare on a "good", "medium", or "bad" day. Rather than having Jen rank the two on a scale, the team asked her how using a syringe vs the product would compare on different days; and similar qualitative descriptions were used to describe the difference between preparation and maintenance of the two medicine dispensing methods. In total, the team simply asked Jen to compare the two products rather than rate them.

For the Jen Usability Feedback Test, the team initially had to change the amount Jen would use the product prior to giving feedback. In the proposal, the team outlined a plan to have Jen use the product in some capacity for a few days. Neither the team nor Jen was able to wait that long to provide feedback, and as the product does leak sometimes, it was not reasonable to ask Jen to carry the product around with her for any extended period of time.

3 mL Delivery Repeatability

The team completed the 3mL Delivery Repeatability Test in order to evaluate the product's accuracy and repeatability of the 3mL dosage. The team used 30 samples and multiple users in order to account for variations in the data. The amount of liquid dispensed for each sample was compiled in Figure 1 below.

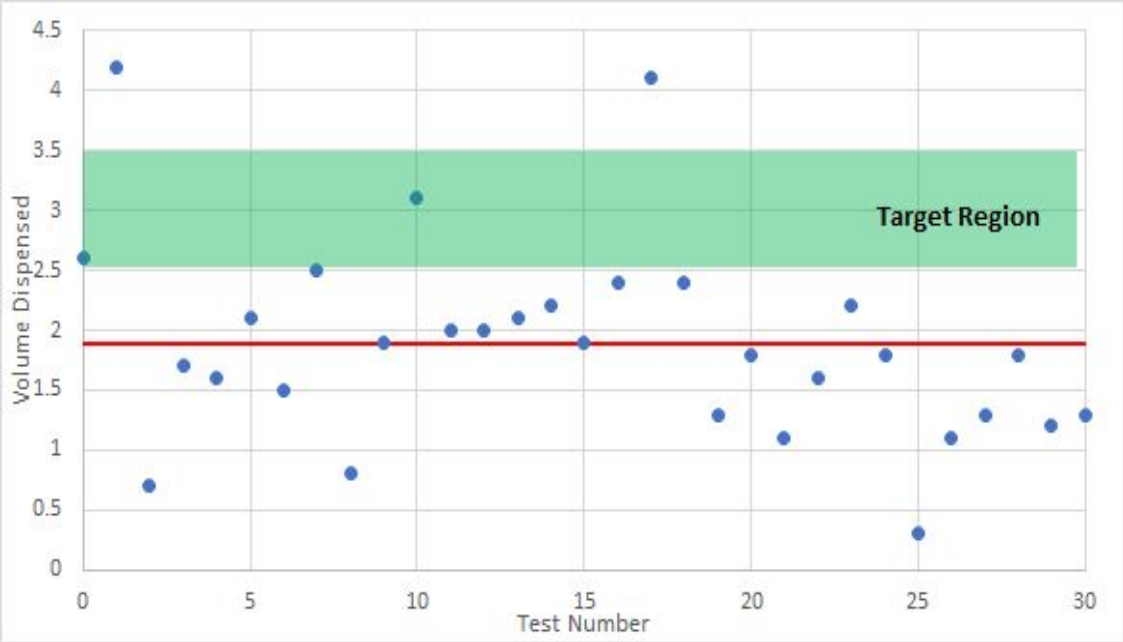
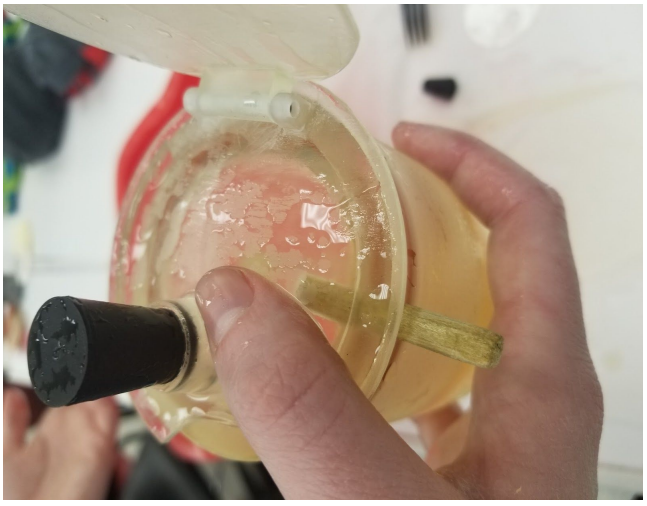


Figure 1: 3mL Dispense Repeatability Test

The mean amount of liquid dispensed per sample was 1.89mL with a standard deviation of 0.85mL. During our initial research, Jen said her dosage should be within 0.5mL of the prescribed amount as indicated by the green box in Figure 1. Only 10% of samples fell within the target range. The team determined that these results were not adequate for a final product, and thus future product development is required prior to using the product as a medical device. For safety purposes, 3 standard deviations should fall within the target range.

The evaluations did lead the team to other important observations about the product. It was found that when the bottle was upright and liquid was in the uppermost section (after the cap was filled but before it was dispensed), liquid would leak at the mesh point between the middle section and the cap. The o-ring in place was not an adequate solution to prevent leaking at this point. This leaking was a large reason the dispensing volume was lower than desired. Overtime, liquid leaked out of the side of the product as shown in the figure below. Leaking would need to be prevented in future product development before the product was in full and regular use.

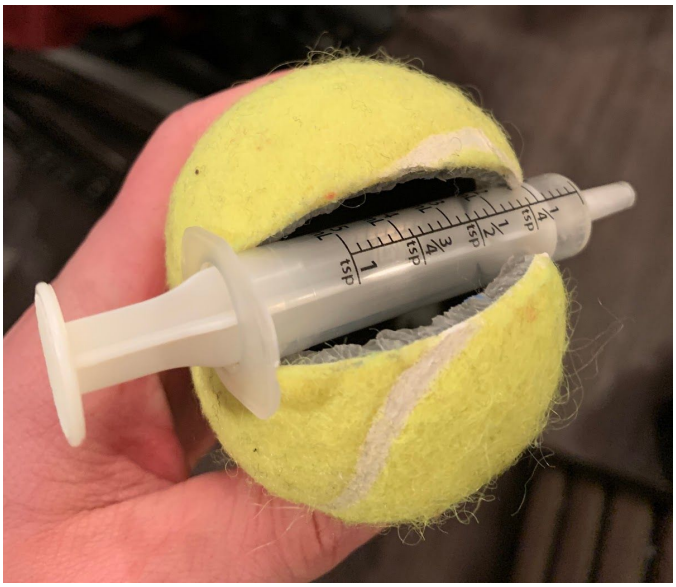


It was also found that the middle rotating part should be modified in future work to increase the part's strength. Either increasing the thickness of the part or changing the material could improve the product as the lever snapped off during repetitive testing.

Usage Time for Bottle vs. Syringe

The team also completed a Comparison of Usage Time Evaluation by having our user, Jen, simulate both her standard "syringe and adaptive tennis ball" pre-meal process as well as the proposed prototype alternative of the bottle using a pseudo-medicine created using cough syrup and water. These simulations would be timed and there would be multiple simulations performed in order to verify the accuracy and consistency of each trial respective to the form of medicine dispensal. The first syringe trial was performed where Jen placed the syringe vertically in the tennis ball and was recorded at 35.6 seconds to completely perform the procedure; and the second syringe trial was performed where Jen placed the syringe horizontally in the tennis ball and was recorded at 25.1 seconds to finish the process. These different methods correspond to varying strategies Jen attempts depending on her physical condition she feels that day, with the average time determined to be 29.3 seconds per use using the "syringe and

adaptive tennis ball” process. We also discussed with Jen the inefficiencies of her current system, including her energy exertion and time/ease of syringe preparation for the week. Next, the bottle process was simulated by our user through multiple iterations in order to compare her energy exerted, the bottle usage time, and a general contemplation in efficiency of preparation. The time of each of the 3 bottle trials were 16.6 seconds for the first, 16.3 seconds for the second, and 16.5 seconds for the third; this resulted in an average time of usage to be approximately 16.5 seconds per use.



It is very clear from the data above that there was a significant improvement in time once using the bottle process as opposed to the “syringe and adaptive tennis ball” process. We see a 44% reduction in usage time, which is definitely significant when determining our overall product success since our aim was to partly improve her regular medicine consuming efficiency. Jen also highlighted other benefits which she would have by using our bottle design in her regular day to day life, such as ease of storage in her wheelchair and features which are much easier to operate than her syringes. Following our time trials, we discussed her energy expenditure when using the bottle, to which she gave constructive criticism regarding attempting to make the device easier to rotate, but also communicated that she believed our product required less physical exertion and fine motor dexterity than her syringe process, which she emphasized would constitute a major upgrade in her daily life. Finally, we discussed her estimation of ease and efficiency in cleaning and preparation of our bottle device versus her current syringe process. Through this conversation, we found that she believed there were several potential benefits for our product’s maintenance and preparation as opposed to her syringes, including the larger pieces for easier handling, fewer number of individual containers for cleaning, and projected longer lifespan of the bottle.

Jen Usability Feedback

The team completed a Usability Feedback Evaluation by interviewing Jen and allowing her to first look at the product, then hold, examine, and simulate use of the product. Throughout the process the team asked her questions. Her comments to our questions were as follows. Aesthetically she liked the look and shape of the bottle, one suggestion that she made was to make the lid flush with the cap to prevent accidental

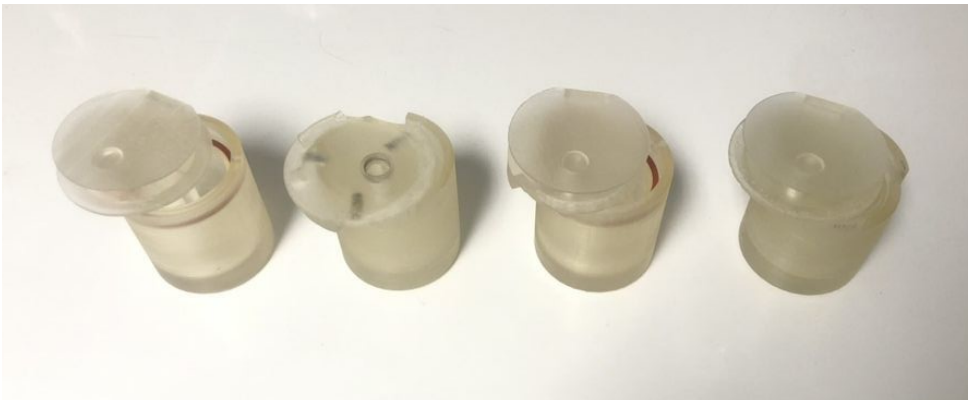
opening due to the space between the lid and cap. She believed that the bottle size was appropriate for carrying in her backpack or wheelchair pouch and commented that since it is similar in size to a glass it was very easy to hold and maneuver. She liked the “snap” lid design and was a fan of the small spout and commented it’s not too big that liquid spills when drinking but it’s not too small so that the liquid can’t come out. In relation to the overall feasibility of the design, she would prefer the bottle method over the syringe method because the bottle method removes the need to use a tennis ball and alleviated the difficulty of removing the cap from the syringe.

For the thumb scroll she liked the added texture on the top and bottom but suggested adding more texture to the sides and potentially adding a larger knob that was softer for days where she had less energy. She commented that in order to make the FILL/LOCK terminology more applicable to everyday users, she would replace the FILL with POUR, and suggested CLOSE instead of LOCK which are more ADA style terminology. She really liked the “storage unit” function because it would allow her to carry doses for a couple of weeks in one place and said that an added freezer pack would not be a problem for her to grab each day. When asked about energy expenditure saved, she said the bottle design would be much easier and require less energy for her on her bad days. She commented that although the weight is more than the syringes, the amount of exertion she spends when dealing with the syringe caps and difficulty of the process with the tennis ball would be avoided and much less frustrating for her. When asked about her time expenditure on a bad day vs. a good one, she commented that the time for her to use the bottle would likely double whereas using the syringe typically her time is tripled. When asked about potential cost savings she said that the it typically costs $10-20 for a new pack of 50-100 syringes every 3-6 months so to purchase a bottle for around $20 would be comparable.

This evaluation gave the team more insight into qualitative areas of the bottle that only someone with a fine motor skill deficiency would notice, and was successful in proving that the design concept would achieve the goal of reducing Jen’s time and energy usage when she takes her medication. Also, having another person’s perspective on the design allowed the team to notice some qualitative design characteristics that could be improved upon further prototyping.

Future Product Changes

As a result of the evaluations performed to assess the functionality and user compatibility of our final bottle prototype, there were several features and design decisions that were revealed which could require increased attention, enhancement, or remodeling upon future iterations of product development. The primary future change that will be needed which was revealed through our testing was the shortcomings we faced in leakage control and dosage consistency - specifically determined from our 3mL Delivery Repeatability Test. Throughout our design process, we were under the impression that simply incorporating o-rings along the paths of movement and connecting parts would allow for a tight enough seal and make sure our prototype functioned properly. This was due to the fact that in testing our aluminum-based Prototype 4: Works-Like Prototype, our team found that the o-rings were sufficient to allow for proper functionality. However, due to the difference in materials (Aluminum vs. SLA) and the difference in tolerances that result from the inherently distinct manufacturing processes, our final prototype did not meet the same successes in functionality. The best solution our team foresees to correct this issue is to attempt building future prototypes with different manufacturing processes which would allow for tighter tolerancing. Another potential solution pathway is to redesign the separation plate which separated the medicine basin from the dosage container, as the majority of leakage occurred within the connections attached to this part. Improving the sealing that occurs on the mechanism which opens and closes the filling channel will be imperative to the design of the next prototype iteration as the primary focus will be turned to consistent functionality.



Aside from the primary functional design changes that will be required in future prototypes, there were also several features revealed in our Usability Feedback Evaluation from Jen which highlighted key areas for improvement in future works in this project. One insightful claim Jen made was regarding the thumb scroll surface, and her desire to see more texture added to key areas which would allow her to have a better grip and access to rotating the disk with her stronger fingers. Another future change to be made, which would help improve the force required to rotate the separation plate, is to change the materials used in our o-rings or to add some lubricating material to the path which compresses the plate within the bottle's structure. A simple change to be made will be the altering of the side labels for the different positions of the product's states from FILL/LOCK to POUR/CLOSE, to be more compliant with certain ADA terminology that Jen is very familiar with. Finally, a major change that would be made to a future product would be to make the lid opening flushed with the top of the bottle, so as to prevent accidental opening of the bottle when in contact with other things. These future product changes could go a long way in further improving our final prototype to a more finished state.

Future Testing

Future testing could be greatly improved if the team had more time to evaluate the final product with the user. This product would lend itself greatly to a diary studies research method. As the user designed user group is relatively small, it would be helpful to have the user provide extended feedback on how she interacts with it on a regular basis and for an extended time. Unfortunately, the team had to rely on quick feedback evaluation methods, but perhaps more thorough information could be found overtime.

Additionally, future testing could be improved by extending the user group to more users. The team was working with a single user throughout the process, but once a slightly more functional product is created, research could be taken to other users as well. A focus group could be set up with physical/occupational therapy clinics and nursing homes to reach users that face similar issues as Jen. Future products could be improved if a larger audience was considered. While the team does not want to consider a one size fits all solution to the problem, the team could consider how the product could improve to a one size fits some solution.

Conclusion

Overall, the product still requires a significant amount of work in order to be a functional prototype. While the user offered several key changes, her overall response was positive as she saw potential in the work that had been done so far. The limitations of materials and equipment at the team's disposal throughout the prototyping process had a large impact on the final prototype quality. Were the product to be made out of flexible consumer plastics, several continuous issues could have been resolved. The future work described in the previous section would be the best next course of action were the team to continue work towards this product.

Rubric

Criteria Description	Excellent Rating	Good Rating	Poor Rating	Bad Rating	Pts
Evaluation Goals	Three evaluations were performed. The tests that were conducted were relevant to develop a quality evaluation of the prototype. The team clearly evaluted areas of the protoype they were not confident in. Tests were chosen that could allow the team to measure the prototypes ability to meet product specifications. 6 Points	Three evaluations were performed. The tests that were conducted were relevant to develop a good evaluation of the prototype. The team did not tests areas of weaknesses in the prototype. Tests were chosen that could mostly allow the team to measure the prototypes ability to meet product specifications. 5 Points	Three evaluations were performed. The tests that were conducted were not fully relevant to develop an evaluation of the prototype. The team did not tests areas of weaknesses in the prototype. Tests were not chosen to allign with product specifications. 3 Points	Fewer than 3 evaluations were performed. 0 Points	
Quantitave Data	Data was sufficiently collected through tests. Test procedures were clear and followed well unless specifically noted to achieve more useful results. Sample sizes were reasonable, and the team inacted measures when appropriate to reduce bias. Testing was well documented. 8 Points	Data was collected through tests. Test procedures were clear and mostly followed. Sample sizes were reasonable, and the team inacted measures when appropriate to reduce bias. Testing was documented. 6 Points	Data was collected through tests. Test procedures were unclear or not followed. Sample sizes were not reasonable. Testing was documented. 3 Points	Data was either not collected and not documented. 0 Points	
Evaluation Results/ Conclusions	Reasonable and applicable conclusions are drawn from evaluation procedures utilized. Team assesses validity of results and specifically states areas of fault and methods for improvement. Emphasizes successful features and details reasons responsible. Overall, team held integrity of evaluation process and arrived at conclusions consistent with the successes and failures reached during evaluation. 7 Points	Reasonable conclusions are presented from all evaluations, but lack depth of understanding into why certain areas were more or less succesful than anticipated. Validity of results are presented, but do not fully demonstrate how appropriate improvements can be made to design. Succesful features are stated and discussed in some fashion. Integrity was held at all stages of evaluation process and generating conclusions. 5 Points	Conclusions are reached as a result of the evaluation process, but they are inconsistent with the obtained data and results. Team does not fully explain specific successes and limitations of final design. Team fails to defend proper validity of results. Integrity may appear to be compromised and some results seem fabricated or insincere. 2 Points	Results from testing are not discussed or mentioned. Conclusions are never considered. Testing practices do not appear valid or meaningful in discerning success of design. Integrity appears completely absent in testing and analysis. 0 Points	
Future Improvements	Future insight was gained from testing and evaluation of prototype. Insight was used to predict next steps with final prototype. Insight was validated with results from testing. 5 Points	Future insight was gained from testing and evaluation of prototype. Direction remained uncertain and minimal reasoning was communicated. 3 Points	Some future insight was gained from testing and evaluation of prototype. Direction remained uncertain and minimal to no reasoning was communicated. 1Points	No future insight was gained from testing and evaluation of prototype. The team failed to communicate any insight or next steps. 0 Points	
Professionalism	Results were presented in a professional manner. Presentation was organized and contained no spelling/gramatical errors. 4 Points	Results were presented in a professional manner. Presentation contained minor spelling/gramatical errors. 3 Points	Results were presented in a unprofessional manner. Presentation contained spelling/gramatical errors. 1Points	Results were presented in a unprofessional manner. Presentation was unorganized and contained an unacceptable amount of spelling/gramatical errors. 0 Points	
Total Points:					