DEM Project- UTI Test Strip Group 4- Imhof, Shank, Wehner
Final Report

# "The Pike"

## Preface: Description of our design (Prototypes 1 and 2)

Prototype 1- "The Stick": Prototype 1 consisted of a wooden skewer with notches made in its side shown in Figure 1 to hold a test strip when introduced to a urine stream in addition to a compostable corn-based "plastic" cup as an option to hold the urine if the user did not want to use the stick.

Figure 1: Prototype 1 with strip

Prototype 2- "The Pike": Prototype 2 consists of a wooden skewer with a sharp end that is poked through the test strip and features a barb-like notch to prevent test strips from sliding off as seen in Figure 2. The design for prototype 2 was conceived in the Design Thinking workshop as seen in Figure 3. Additionally, prototype 2 features an origami-style foldable paper cup seen in Figure 4 that is much cheaper to make and decomposes more quickly than the corn-based "plastic" cup from prototype.

Figure 2: Prototype 2 with strip

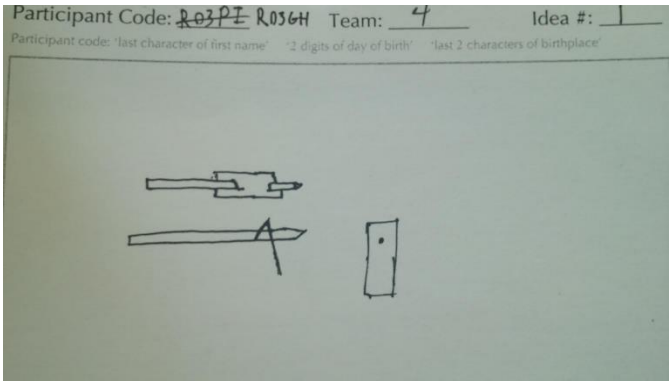


Figure 3: Design Thinking Workshop sketch of Prototype 2

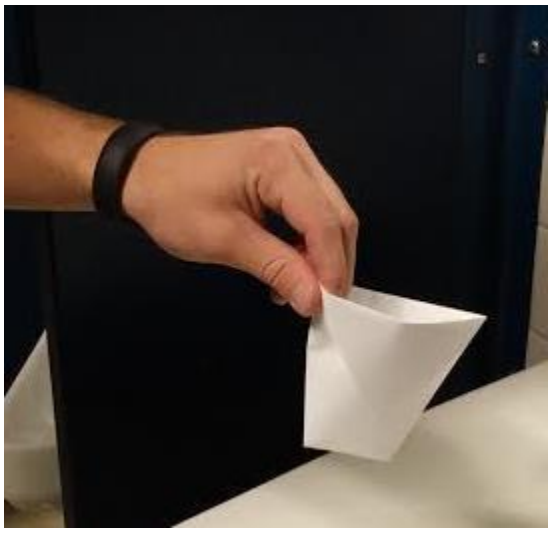

Figure 4: Paper cup

## Testing

<u>Prototype 1:</u>

Major Takeaways from Prototype 1 Testing:

- -Took longer than intended to set up.
- -Held the test strip well.
- -Use of cup was favored.
- -The cup and stick are locally available in Rwanda
- -The device is compostable within a year.
- -System costs 6.17 cents per unit

Table 1: Test Results Summary (Prototype 1)

| **User Need/ Feature/Requirement** | **Summary of Test** | **What is "pass"?** | **Materials Used** | **Recorded Value** | **Pass or Fail?** |
|---|---|---|---|---|---|
| a. Device can be set up quickly | Time how long it takes a randomly selected classmate to put the test strip between the notches on the skewer | Device can be set up in under 30 seconds | Our device and practice test strips | 42, 40, 30 24 seconds, average of 34 seconds | Fail |
| b. Device holds up when put in stream of liquid | Place device with test strip in water fountain and see how long it holds the strip on | Device holds the strip for at least 30 seconds | Our device, practice test strips, and a water source | In all trials the device held the strip for more than 30 seconds | Pass |
| c. Option to use cup | Survey people to see if people would like | Majority of people (14) surveyed want to use cup | Paper for taking class survey | Votes for yes: 8, Votes for No: 6 | Pass |
| d. All resources are available in Rwanda | Research which materials are available in Rwanda | All products can be purchased in Rwanda | Computer for Research | Skewer and cup are both available in Rwanda | Pass |
| e. After use, device will produce a minimal amount of waste | Research to see if all materials can decompose quick enough to be considered nearly waste-free | All materials can decompose (more than 95% of material gone) in 12 months or less | Computer to research information | Wood skewer- 9-12 months (in industrial composting) Cup- about 12 months ("Can I Compost") | Pass |

| | | | | | |
|---|---|---|---|---|---|
| f. Low total cost per unit | Research the cost of all materials for one test unit | One test unit costs less than 10 cents | Computer to research information, calculator to calculate unit price of bulk-order items | 6.17 cents per test unit (0.17 cents per skewer and 6 cents per cup) | Pass |

<u>Test Observations Summary (Prototype 1)-</u>

a. We conducted four trials of setting up the device. Three involved randomly selected students from our class and the final trial was done by a member of our team. Trial one took 42 seconds, trial two took 40 seconds, trial three took 30 seconds, and trial four took 24 seconds, making setup time an average of 34 seconds. Since our target time was a setup of less than 30 seconds, the prototype fails this test. We were surprised because we thought our idea would be more intuitive to other users.

b. In the second test, we subjected our prototype to several different streams of water (Figure 5a-c) as well as holding onto the wet strip after it was placed in a cup of water (Figure 6). We began with a light stream of water (a), then used a medium-level stream (b), and then used the faucet was turned the whole way up (c). In all trials, the paper test strip stayed on the prototype well after 30 seconds and until the paper disintegrated.

Note: The actual test strips are made from Teslin® (a stronger type of paper) and would not disintegrate while put under a stream of water. We used regular paper as an example as we could not obtain a sample of Teslin® paper for prototyping.

(a) Strip on Prototype 1 in trial 1

(b) Strip falling off Prototype 1 60 seconds into trial 2

(c) Strip breaking off 45 seconds into trial 3

Figure 5: Second Test of Prototype 1

Additionally, the paper stayed on the skewer after keeping it in the cup for 30 seconds (Figure 6)

Figure 6: Submerging Prototype 1 and test strip into cup of water

c. The results of our survey on cup usage in Prototype 1 showed that our class leans only slightly more towards wanting a cup. Although our using a cup only won out 8 to 6, all of the female volunteers opted for having a cup and so that fact must be taken into account. Therefore, having the ability to use a cup would be worth adding to the design.

d. We found that both major parts of our current prototype, the compostable plastic cup and the wooden skewer, are available locally in Rwanda. For the compostable cup, the Danish company Nordic EcoFlex, a producer of compostable plastics, does almost all of its factory production near Kigali, Rwanda ("Nordic Ecoflex- Information"). By having this production done locally, the ecological footprint of having to import these supplies and potentially some of the price could be mitigated. As for the skewers, many native Rwandans produce them in villages to be used for lamb brochettes, a popular food in Rwanda (Cole). Since both are available locally in Rwanda, our prototype passed this test.

e. While it would have been ideal to test the decomposition times of the exact materials we would be using, it would have taken an impractical amount of time. Instead, we used online research to estimate that a decomposing skewer would take around 9-12 months ("Can I compost") and a Nordic EcoFlex cup would take around 12 months to decompose in industrial composting ("Nordic Ecoflex- Information"). Since both would take around 12 months to decompose, the prototype barely passed this test. We found this information surprising as were skeptical that the compostable cup could decompose within a year and thought the skewer could decompose a bit quicker than 9-12 months.

f. Our information for the price of the skewers came from Jared Cole, a conservationist who travelled to Rwanda, who noted that villages in Rwanda produce around 100 wooden skewers in exchange for around 100 Rwandan Francs, about 17 cents (Cole). After doing the math, each skewer would cost 0.17 cents apiece. Although prices were not available for the Nordic EcoFlex cups without an official business inquiry, we found prices for a similar product (3oz cup) which costs $7.70 for 125 cups ("Ingeo"). After doing the math, this came out to around 6 cents per cup. Together, the two parts of the prototype come out to be 6.17 cents and pass the test.

Prototype 2:

Major Takeaways from Prototype 2 Testing:
-Strip can be put on stick in under 30 seconds
-New stick can still hold the strip well
-New cup design is significantly cheaper than the previous one
-New paper cups can effectively hold water
-Use of new paper cup design is favored
-Entire system (cup and test strip on stick) can be assembled in under 2.5 minutes

| **User Need/ Feature/Requirement** | **Summary of Test** | **What is "pass"?** | **Materials Used** | **Recorded Value** | **Pass or Fail?** |
|---|---|---|---|---|---|
| a. Device can be set up quickly | Time how long it takes a randomly selected person to put the skewer through the test strip | Device can be set up in under 30 seconds | Our device and practice test strips | 23, 21, 19 25 seconds, average of 22 seconds | Pass |
| b. New stick can effectively hold test strip | Place device with test strip in water fountain and see how long it holds the strip on | Device holds the strip for at least 30 seconds | Our device, practice test strips, and a water source | In all trials the device held the strip for more than 30 seconds | Pass |
| c. New design with folding cup is still cost-effective | Research the cost of all materials for one test unit | One test unit costs 6.17 cents or less | Computer to research information, calculator to calculate unit price of bulk-order items | 1.17 cents per test unit (0.17 cents per skewer and 1 cent per sheet of paper) | Pass |
| d. Paper cups hold water well enough to introduce a test strip to the urine | Time how long folded paper cup holds water before falling apart | Cups filled with water last for more than 45 seconds | Folded paper cups, water source, timer | In three trials, the cup lasted 93, 104, and 97 seconds before leaking | Pass |

| | | | | | |
|---|---|---|---|---|---|
| e. Use of new paper cups will be favored by people | Survey people if they would use the new paper cup | More than 75% of 32 surveyed people would use the cup | Paper for taking survey | 27 out of 32 people (84%) surveyed said they would use the cup | Pass |
| f. Image instructions we generated are effective | Give people image instructions and see if they can assemble the cup and put the test strip on the stick | At least 80% of 10 people who volunteered could completely assemble the device in 2.5 minutes or less | Image instructions, paper for making cup, our device, sample test strip | 9 out of 10 (90%) volunteers completed the assembly within 2.5 minutes | Pass |

<u>Test Observations Summary (Prototype 2)-</u>

a. For testing the time of setup for Prototype 2, we had 4 random students at Penn State put a sample test strip on our prototype and timed them doing it. By taking random students instead of students from our class, we had a better idea of how long it would take people who do not know much about the project to set up our device. In trial 1 (Figure 7), it took the person we asked 23 seconds, in trial 2, it took 21 seconds, in trial 3 it took 19 seconds, and in trial 4 it took 25 seconds. Together, these times averaged to be 22 seconds and since strip was put on our prototype in less than 30 seconds every time, it passed the first test.

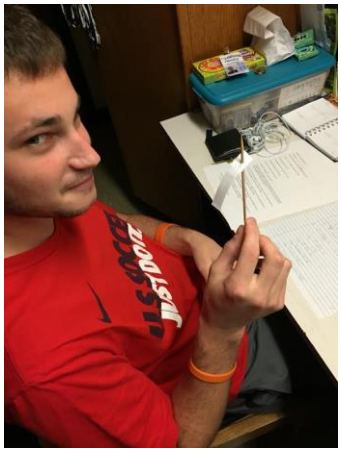

Figure 7: Trial 1 of device setup

b. In the second test for Prototype 2, we essentially conducted the same test as we did for the second test for Prototype. Just like our initial trial, the prototype successfully held the test strip for over 30 seconds in all three different streams of water.

c. When evaluating the price per unit of our new prototype, we used the same price for the skewer as before (0.17 cents) as that portion of the prototype did not change except for the shape of the cuts made in the skewer. Since the corn-based “plastic cup” is not part of Prototype 2, we could eliminate that price and instead add the price of the skewer to the price of one sheet of recycled paper. Although we could not find a Rwandan dealer for paper, we found the price of 5000 sheets of paper from Officemax and assumed that Rwandan prices would be close. 5000 sheets cost $64.29 (“Aspen 100% Recycled Paper”) so one sheet of paper was about one cent after doing the math. This made the total price per unit of our prototype 1.17 cents. This was significantly cheaper than Prototype 1’s 6.17 cent unit cost, so Prototype 2 passed this test. (Note: although we didn’t explicitly test for this in Prototype 2, it is worth noting that changing from the cup to paper would shorten composting time as paper will disintegrate in a few weeks rather than 12 months as the cup would).

d. In testing the foldable paper cup with water, our design fared surprisingly well. We filled up 3 different test cups with water (Figure 8) in 3 different trials and timed how long the cups held water before falling apart of leaking (Figure 9). In our three trials, the cups lasted, 93, 104, and 97 seconds. Since these were all well over the required 45 seconds, Prototype 2 passed this test.

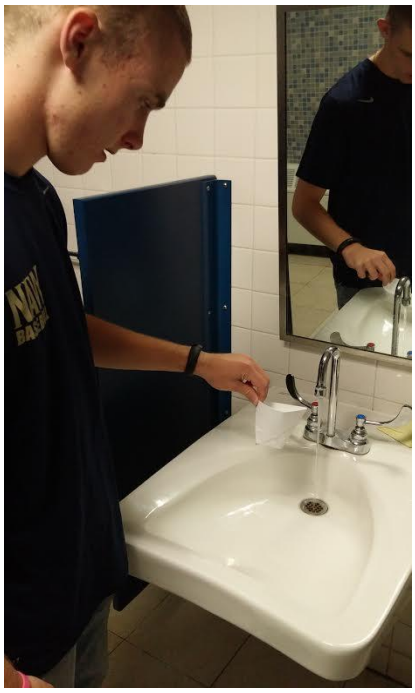

Figure 8: Filling a test cup up with water

Figure 9: Examining a cup right before it began to leak
(note how the paper is saturated with water)

e. In our survey for cup use in Prototype 2, we surveyed many more people than we did for Prototype 1. This allowed us to have a much better look on how many people in a population would want to use a cup in a urine test. Out of 32 people surveyed to see if they would use the foldable paper cup in a urine test, 27 people (around 84%) said yes. This was more than the required 75% so Prototype 2 passed this test.
f. In our final test for Prototype 2, we gave 10 different people our image instructions, a piece of paper for making the foldable cup, our prototype device, and a sample test strip and then recorded the time it took them to assemble the entire system after they were given a few minutes to learn how to set it up. This is shown in Figure 10. After testing 10 different people, 9 of them (90%) were able to set up the prototype within 2.5 minutes. Since this was greater than the required 80%, Prototype 2 passed this test.

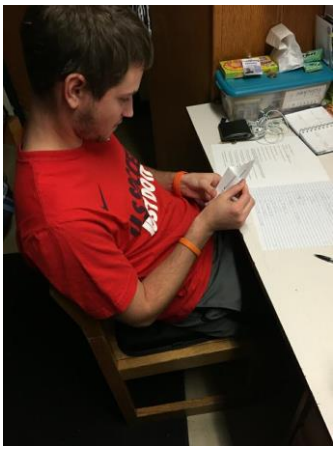

Figure 10: One of our volunteers setting up Prototype 2
from image instructions

## Cost Analysis

[Refer back to Test Observations Summary (Prototype 2) part c. for information on how the cost per unit was determined]

In our prototype, we made a few trade-offs in design to keep our unit price so low. For example, the use of additional materials to aid the use of the test strip was minimized in an attempt to keep the price of each test as low as possible and to keep waste minimal. These efforts paid off because by having a unit cost of 1.17 cents, an already effective test can be manipulated a great many times as it is extremely affordable even in the poorest of regions.

## User Guides

To ensure no error in UTI test strip use, we decided to print instructions on how to fold the cup and how to put the test strip onto our device. The test strip instructions are to be ripped off the sheet so the rest of the paper is square and can be used to show how the cup will be folded. Figure 11 shows the front of this page and figure 12 shows the back.

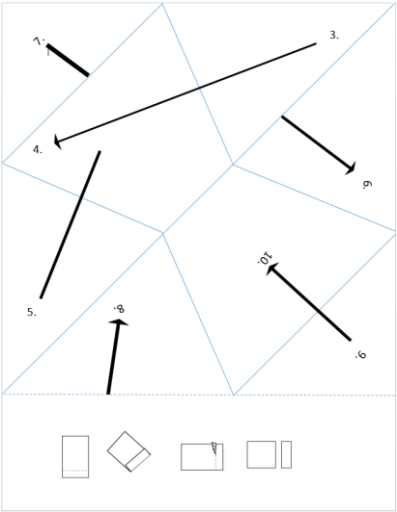


Figure 11: Front of instruction sheet

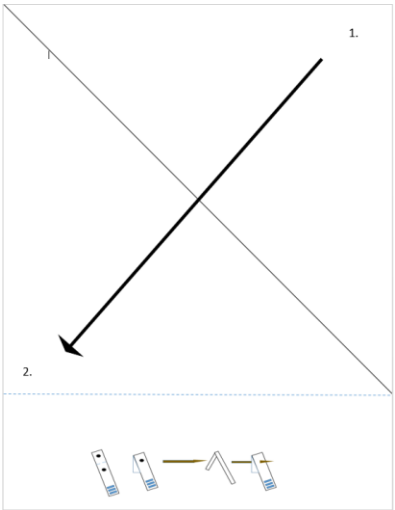


Figure 12: Back of instruction sheet

Additionally, we would include a paper showing an example of a positive test strip as well as instructions outlining safe disposal technique for UTI test strips. This paper is shown in Figure 13.

After use one should empty their cup and place it in a compost pile. The same should be done with the pike and test strip after the results have been viewed and recorded.

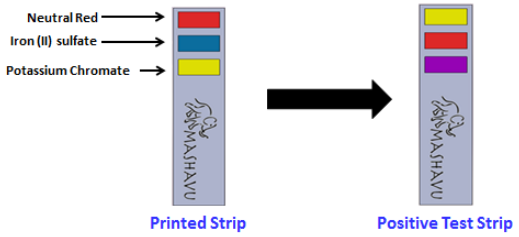


Figure 13: Positive strip/safe disposal technique paper

## Re-design ideas/thoughts

There is not much to change in our design in Prototype 2, but if we had the opportunity to make a third prototype, we would most likely reduce the amount of wood used in each wooden skewer to further lower the cost and have less waste. Also, when we were testing the device, we realized that it was sometimes difficult to put the wooden skewer through the piece of paper we used in place of a test strip. Since the real Teslin® test strips will be thicker, they would be even harder put on the skewer. To solve this, we could add a hole to each test strip that is smaller in diameter than the skewer to make the process easier. Finally, we could perforate the part that is torn off the cup folding instruction sheet to make tearing off the instructions easer. However, all of these changes would only be made if they did not greatly raise the cost of production.

Works Cited

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