HIV Barrier Model

Final Report

Fall 2010

Biomedical Engineering Department

University of Wisconsin

Wan-Ting Kou - Leader

Bret Olson - Communicator

Lisle Blackbourn - BWIG

Albert Wang – BSAC

Client: Dr. Marge Sutinen

Advirsor: Chris Brace

ABSTRACT

HIV is a prevalent infectious disease worldwide. Although it is more common in third-world countries, it is a problem in the United States as well. Our client, Dr. Marge Sutinen, requires a portable device that demonstrates the strength and durability of condoms against HIV infection and other sexually transmitted infections. She plans to use this device in her class, *Contemporary Issues is HIV/AIDS*. Many design alternatives were considered including: free falling medal rods, water/dye, and beads, as well as folding and telescoping poles. After testing each idea with the old model, we decided on a final design based on matrices. The final design utilizes water with telescoping poles on a hand trolley. This design will give Dr. Sutinen and her students the desired dramatic effect necessary to capture the attention of non-believers.

1.0 Introduction

1.1 Background

1.1.1 HIV Current Issues

Human immunodeficiency virus or HIV is a sexually transmitted disease that slowly destroys the human body's ability to fight off infection (National Institute…, 2004). When the immune system is weakened to a CD4+ T cell count lower than 200, the disease is then classified as acquired immunodeficiency syndrome or AIDS. Transmission of HIV can happen through blood or the secretion of other bodily fluids. Because of this, one of the most common ways HIV can be spread is by having unprotected sex with an infected partner. The HIV virus can enter the body through the lining of the vagina, penis, rectum, or mouth during sexual contact. Since there is no vaccine or cure for HIV, the only way to prevent infection is to avoid unsafe or risky behaviors such as having unprotected sex.

The simplest way to protect oneself during sex is to wear a condom. It has been shown that wearing a condom during sexual intercourse reduces the chances of spreading HIV by 80% (Weller, 2002). This makes it especially important for people to know the strength and protection a condom provides. Also, it has been estimated that one-quarter of those infected with HIV are unaware that they have it (National Institute…, 2004). With the lower cost of condoms, it is important to wear one even if you think you or your partner is unaffected. Knowing these facts leads to more consistent condom use and greater protection from HIV infection.

The University of Texas has been doing leading research that has shown the effectiveness of condoms and condom use (Pease, 2000). The study tracks volunteer couples with one partner HIV positive and the other HIV negative. Consistent condoms users saw 0%, 1%, and 0% of HIV infecting the partner in the US, Haiti, and England respectively. While inconsistent condom users saw their partner get infected 10%, 6.8%, and 4.8% of the time in the US, Haiti, and England respectively. These statistics show that consistent condom use is a great way to protect unaffected partners.

1.1.2 Current Condom Testing Techniques

The Food and Drug Administration, as well as private condom companies, perform a variety of tests on condoms to make sure they are up to federal regulated standards. If 5 condoms out of 1000 fail these tests, the whole batch cannot be sold and is discarded. One such test is the tensile or strength test. In this test, the condom is cut into circular disks and each disk is tested to see how far it can stretch. To pass, the condom must elongate 650% and be subjected to at least 17 N of force (Schellstede, 2010). Another test is the water leak test, where the condom is filled with water to see if there are any pores in the condom that allow water to pass through (Pease, 2000). It turns out that water molecules are smaller than HIV molecules, so a water test can help show that HIV transmission can be prevented by wearing a condom (Schellstede, 2010). The airburst test fills the condom with air to see the total volume and pressure it can withstand (Pease, 2000). Current US standards for the airburst test are having the condom hold a volume of at least 16 liters with a pressure of at least 1 kPa (Schellstede, 2010). In an electrical conductance test, the condom is filled with a small amount of liquid and an electric current is passed through the liquid to see if it is passed through the condom (Pease, 2000). If a hole is present in the condom, the electrical current would be able to pass through the condom. This would indicate a faulty condom.

1.1.3 Current Model

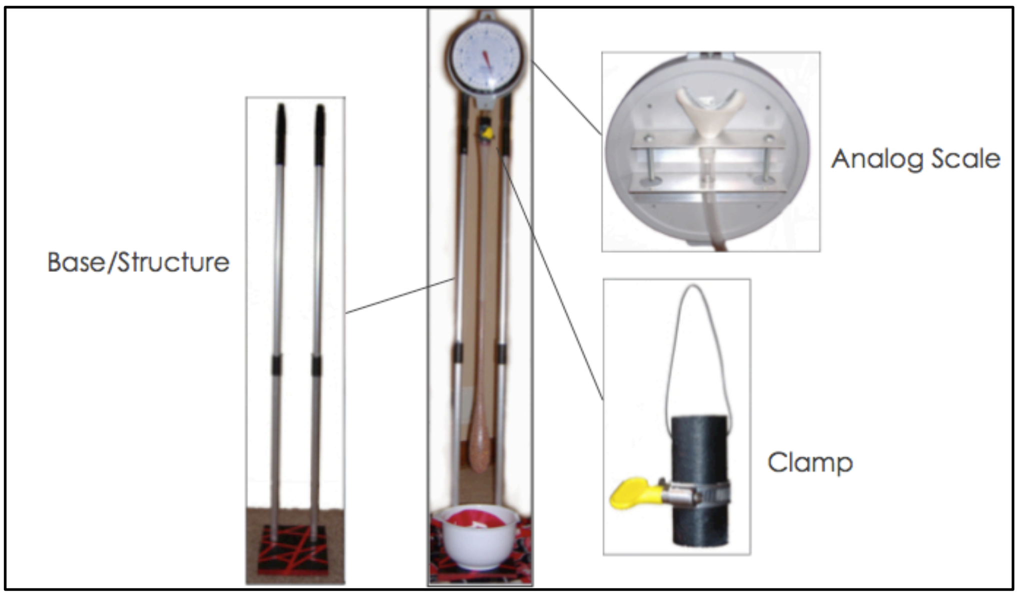


Figure 1: Current Model Apparatus. The current model consists of three main structures: the analog scale, the clamp, and the base/structure. These structural components were evaluated and chosen by the former BME student team in 2009 (Adapted from 2009 Spring BME student team).

The current device (Figure 1) that we obtained from our client was designed and made by a previous BME design team. The base of the device is consisted of a wooden base, and two hollow aluminum poles (about 1.2m in height). An analog scale is attached at the top of the two poles, with a monocircular clamp hanging from the bottom of the scale. The previous design group chose the analog scale over other types of scales, such as digital scale, because it is easy to read from long distance while having an affordable price. Plus, the analog scale does not require any power source and it is relatively light and easy to carry. The clamp apparatus consist of a metal ring along with an adjustable screw, which can be used to tighten and secure the condom (Balge, et al, 2009).

To perform the demonstration, the condom is first tightened to the spout at the bottom of the scale by using the clamp. Then, metal beads are slowly poured into the condom via an attached tube and funnel at the back of the scale. The scale instantaneously shows how much weight has been added to the condom as the beads are poured in. Once the condom breaks after it reaches its limit, the white bucket on the base collects the falling beads

1.2 Motivation

The motivation behind this project is directed at promoting safer sex. It is important to educate people of all ages about the effectiveness, strength, and durability of the condom. Educating people about condoms, will lead to more consistent condom use and therefore, safer sex. When the project client, Dr. Sutinen, went to Africa, she found that many people there believed that condoms had worms in them and that government condoms were not as good as others. She used a similar device to the one we are making to educate the people there about condoms. They were shown that condoms do not have worms and that the government issued condoms were as strong as any other condom. Students in her class, *Contemporary Issues is HIV/AIDS*, may know these facts already, but they still underestimate the condom's strength. After the demonstration of the model, the goal is to improve student's views on their use of condoms. The goal is to portray just how strong condoms can be. With more consistent condom users, it will be less likely to transmit a sexually transmitted disease. This will help create an even healthier campus social life.

2.0 Design Specification

The model that previous design group made has several problems that the client wants to improve. First of all, the new design must have improved portability. In the current model, the device needs to be broken down into several individual parts before it can be transported. This method causes problems for Dr. Sutinen because the previous group didn’t provide any carrier to transport the individual parts. In addition, some parts are bulky, and others are heavy, thus these parts further increase the difficulty in transportation. In order to let the new device become more mobile, the new device must be able to condense for transport, be easy to carry, and be light in weight (target weight: less than 7 kilograms). But at the same time, the model still has to be large enough for big classroom demonstrations. Second, the new device certainly has to be more user-friendly than the current version. This user-friendly topic includes several needed improvements. The current testing method involves pouring metal beads into the condom to show the strength of condom. Once the condom reaches its limit and eventually breaks, the metal beads have a tendency to spill all over the place, making the operator’s job much more difficult. This also creates the opportunity for losing a great amount of metal beads, which are expensive to replace. Even though the current model provides a collecting bowl to collect the falling beads, it is ineffective because it is too small and unstable. Both the collecting bowl and metal beads need to be changed and improved. However, the material (or other presentation mechanism) that is going to replace the original presentation mechanism should still dramatically show the effectiveness and toughness of a condom. The new model also must be easy to assemble and operate for everyone because our client wants everyone even those without any prior knowledge to be able to set up and operate the device with ease. The only requirement for operating the device is that the operator needs to be 1.6 meters tall or taller, so that the operator can do the presentation with ease. With all the new improvements we are adding, the new model should still be inexpensive, meaning costing less than $100, and easily reproduced (The complete Product Design Specification is included in Appendix 10.6).

3.0 Preliminary Analysis

3.1 Preliminary Testing

The group conducted tests with the original BME design model using various weights to stretch the condom. The first weighting system used was the original method of the beads (Figure 2). The various brands of condoms had different results that ranged from a stretch length of 56 centimeters to 97 centimeters before the condom broke (Figure 3). This corresponded to a weight range of 0.68 kilograms to 1.81 kilograms. There was also a problem containing the beads, as they tended to bounce in every direction after the condom broke (The complete testing data can be found in Appendix 10.1).

Figure 2. Testing on original model using beads. On the left, Bret is placing a condom on the old device while the group watches. On the right, Albert is pouring the medal beads into the device. The condom is stretching as the weight of the beads increases.

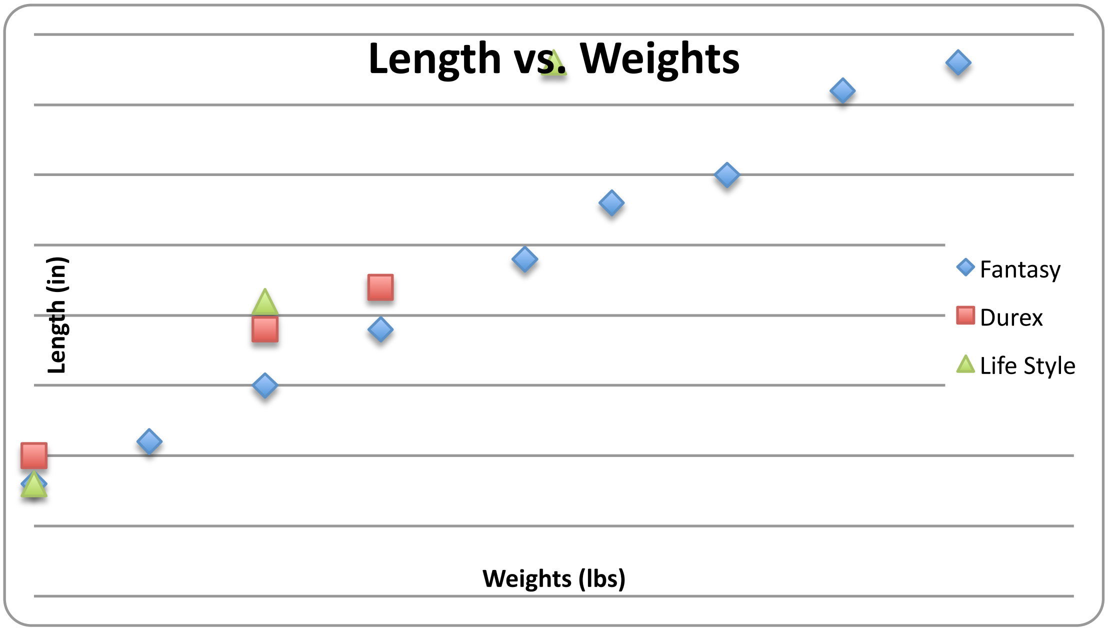


Figure 3: Length vs. Weight for three condom brands. The above graph is a representation of the testing on the original model with the medal beads. Three different kinds of condoms were tested. At various points the stretch length and weight contained in the condom was measured. Each trial ran until the condom broke.

Next, an airburst test was performed (Figure 4). This test was quickly identified as improbable. Although we had an air supply, it was reasonable to assume the client would not have one readily available at all times. Also, there was no way to determine the amount of air it held.

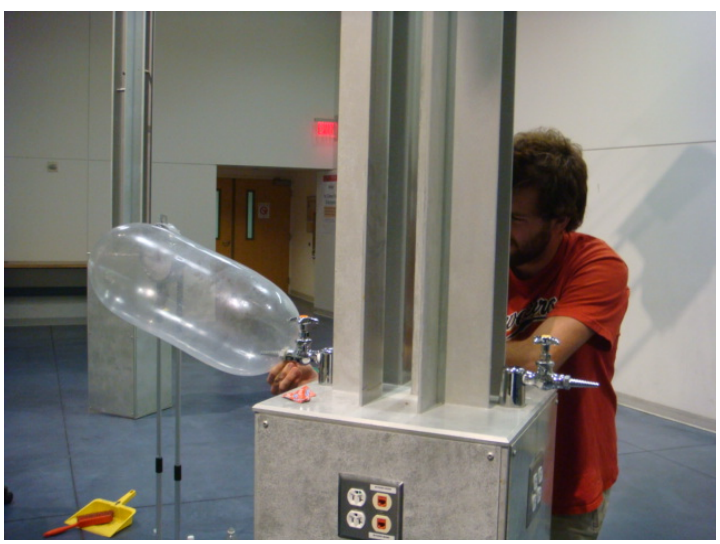


Figure 4: Air burst testing. Bret is performing the airburst test. The only compressed air we had access to was a valve attached to a lighting system in the Engineering Centers Building at UW-Madison. Bret had to hold the condom tight to the valve until it burst.

The group then decided to try dropping medal rods into the condom. This did not work very well as the rod available simply did not stretch the condom as desired. It was determined from this that the size and weight of the rod necessary to achieve the desired effect would be too big for easy operation. Water was also used in the original device. Water testing turned out to be more consistent in terms of weight and the length of the stretched condom (Figure 5). The condom held around 3.40 kilograms and had at least a stretching capacity of 101 centimeters, no matter what brand of condom was used. The water ballooned at the bottom giving it a more dramatic effect to the group than the beads did. When the condom broke, the water tended to fall straight down, unlike the beads. This led us to believe that water would be easier to contain than the beads. This made us believe that water was the best option for our design model.

Figure 5: Water testing on the current model. Above is the old design model performing the water test. The condom was filled with water which stretched the condom to the ground and ballooned the tip of the condom.

3.2 Presentation Survey

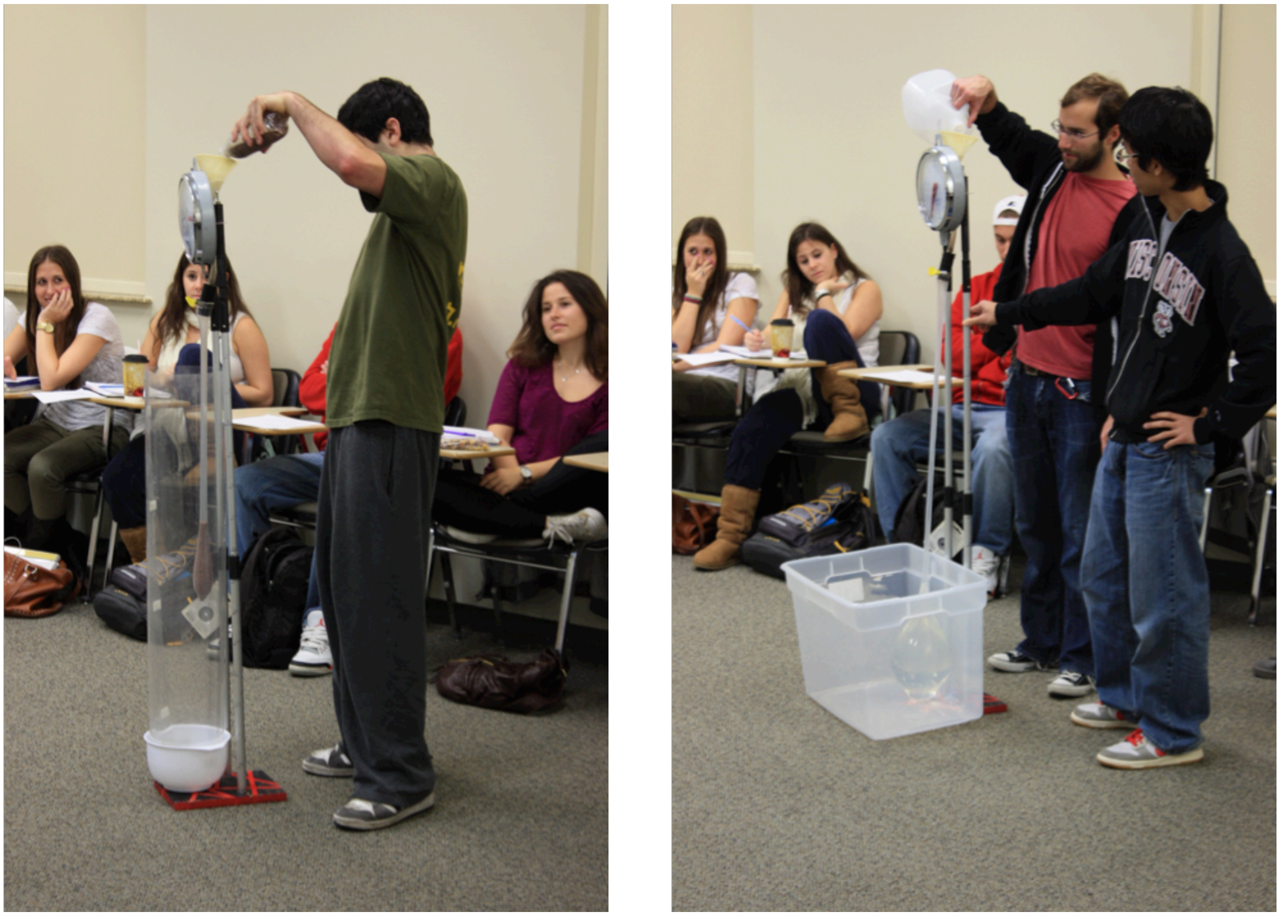


Figure 6. Demonstration in client's class. Two students volunteered for performing the condom testing. One used the beads mechanism (left) and one used the water as the testing source (right).

The design team performed a demonstration in front of the client's students (class name: Contemporary Issues in HIV/Aids Prevention) on 11/10/10 (Figure 6). The old device was used because the design for the new model was not finalized at this point. However, the survey collected from the 35 students greatly helped the design process. There was total of 8 questions on the survey, which were divided into two parts: "Before presentation" and "After presentation". The students filled out the first part prior to the presentation, then performed two presentations with different mechanisms (the original method with beads and then the new idea with water). Finally, the students filled out the rest of the survey (See Appendix 10.2 for the actual survey).

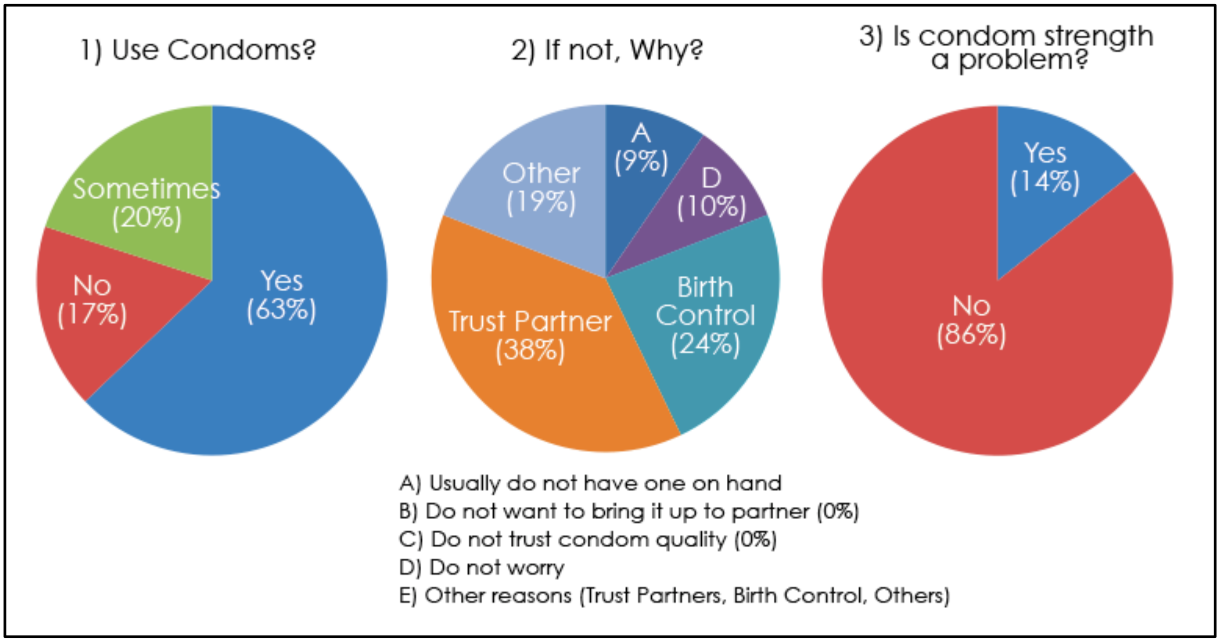


Figure 7. The statistical results of the questionnaire before the presentation.

The results from "Before presentation" indicated that 37.14% of the students do not or sometimes do not use condoms. Most of the people that did not use condoms said that they have different methods of protection other than using condoms (38.46%) or trusted their partners (61.54%), others were simply not aware of the consequences of sexual intercourse and sexually transmitted diseases (refer to Figure 7). Also, 85.71% of the people never think about the strength of condom issue.

From the second part of the survey (after presentation), the group received positive feedback from the students that were surveyed. According to the result in Table 1, 88.57% of the students increased their confidence in condom strength, and 62.86% of them would more likely keep supply of condom on hand after watching the presentation. This showed that the presentation was successful, since most of the students (85.71%) weren't even concern about the strength of the condom. Also, the new presentation mechanism (water) received better grades (88.57%) than the old mechanism with beads. During the presentation with the water mechanism, all the students were stunned by the fact that a normal condom was able to hold more than 3.79 liters (a gallon) of water without any leakage. After we poured 3.79 liter of water into the condom, the students became excited and involved themselves in the presentation. This once again indicated that the presentation, with the new mechanism, was dramatically improved from the previous design.

Table 1: the statistical results of the questionnaire after the presentation.

After Presentation Questionnaire	Yes (%)	No (%)
4) If you do not usually use condoms, did the presentation change opinion on condom use?	71.43	28.57
5) More likely to keep supply of condom on hand?	62.86	37.14
6) Improve confidence in condom's strength?	88.57	11.43
7) Experience of this presentation allows more comfortable conversation with partner on condom use?	60	40
General Feedback on Presentation Mechanism	**Water (%)**	**Beads (%)**
8) Which presentation mechanism (water or beads) was more impressive?	88.57	11.43

4.0 Design Alternatives

Our design process is split into two divisions. One set of ideas is aimed to improve the presentation mechanism of our design, while the second set is for the apparatus that maintains the structure and functionality of our device. There are four alternatives evaluated under the presentation mechanism category: pouring beads, water/dye, a combination of the first two, and a free fall mechanism. The major differences that distinguish the four alternatives are the different materials used as a weight to fill the condom. Each alternative will cause different levels of dramatic visual effect to the audience during the demonstration. This visual effect and a few other categories, to be mentioned later, will determine the final choice for the presentation mechanism. Under the apparatus category, two options are included: folding poles and telescoping poles. Both of the proposed structures are similar to the original because the original design works well, but it has a few key flaws. One, obvious flaw is that one of the current poles is broken, a second important flaw is the lack of adjustability in the current poles. The objective is to fix these two problems with the one of the apparatus proposals.

4.1 Presentation Mechanism

The presentation mechanism division deals with how the strength and durability of the condom will be revealed to the audience.

4.1.1 Pouring Beads (Original)

The pouring beads method was the first to be considered because it is the way in which the current device is operated. During a demonstration, the presenter opens and unravels a condom. The condom is then placed on the opening of a spout attached to a weight scale. The attachment is then made secure by a hose clamp that can be tightened by hand. Once the condom is secured in place, tiny, round copper beads are poured into a funnel at the back of the scale that leads to the spout inside the condom (Figure 8). As the copper balls are poured in, the condom stretches and the scale measures the increasing weight. The pouring continues slowly until the condom bursts. This process leads to impressive displays because the weight of the beads causes the condom to stretch upwards of four feet. Another great feature of the pouring beads method is the fact that

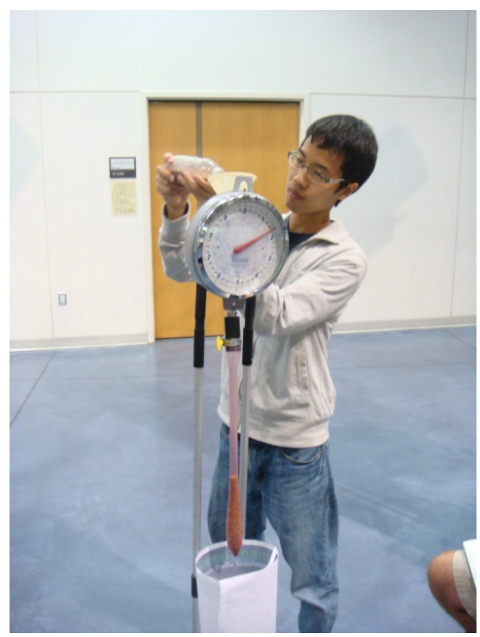


Figure 8. The Demonstration Mechanism of Pouring Beads.
One of the team members is performing the demonstration by pouring the metal beads into the current device.

the beads can be distributed to the students in the classroom; this way they can physically feel just how much weight the condom will hold. Additionally, given our relatively small budget of $100, using this design would allow us to use many of the same parts from the original device. However, the pouring beads method has one major drawback. The geometry of the beads causes them to creep up the condom as they are being dispensed. This is not a problem as far as the visual effect of the presentation is concerned, but when the condom bursts the beads that are at the middle and upper portions of the condom (furthest from the ground) tend to scatter in an uncontrollable manner. This unfortunate effect leads to the loss of beads, and a difficult clean up. The original design would need to be improved by making a better *bead catching* mechanism, which may lead to less visibility of the actual presentation.

4.1.2 Water Dye

The water dye design uses the same basic mechanism as the pouring beads method, but incorporates water as the weight entering the condom instead of beads. Through the preliminary testing discussed previously, we found that condoms of many varieties consistently held more water weight than bead weight. This is most likely due to the fact that the water load is more evenly distributed against the condom walls than the beads' load. Furthermore, since the water is less dense than the beads a much greater volume of water can be held by the condom. As one might imagine, the dramatic effect caused by the greater weight and volume of the water is notable. Moreover, the survey described above found that about 89% of students enrolled in *contemporary issues in HIV/AIDS* here at UW-Madison found the water display to be more impressive/dramatic. The water dye presentation mechanism also benefits from the fact that it can be used in two separate, but equally effective ways. The first technique would be the standard procedure, in which the water is poured slowly into the condom until the condom breaks. The second technique would involve using food coloring to dye the water that is being poured into the condom, preferably a color noticeably different from clear water (i.e. red, blue, green, etc.). The condom would be filled to a predetermined volume that would ensure that the condom would not break but would also make certain that the condom was fully stretched. Many tests would need to be performed before the first presentation to ensure that the volume chosen satisfied both the above categories. Not to mention the possibility that different brands of condoms may need to have specific predetermined water volumes. Nevertheless, after the condom is filled to the preset volume of dyed liquid, the large bulb that forms at the end of the condom would be placed in a water-tight vessel containing clear water (Figure 9); as the condom sits in the pool of water it will become obvious to the observer that the condom is sufficient barrier between the dyed liquid and the clear water. That is, even under the tremendous strain of the large volume of dyed liquid suspended inside, the condom is still able to fulfill its purpose of preventing transmission. This presentation is powerfully dramatic because it focuses the observers' attention on the most important quality of the condom, its ability to prevent the transmission semen or diseases, especially HIV. It is important to note that water molecules are even smaller than the HIV molecules (Schellstede, 2010). This means that a water test is beyond effective for testing a condoms ability to prevent transmission. This type of demonstration would give our client a much more realistic way of looking at the strength of a condom. Although water is what makes this design appealing, it may also be its downfall. Water is difficult to transport, and spills are a real concern. A water-tight basin to catch the water after the condom bursts is essential and it needs to be large enough to prevent any spill because these presentations are generally held in classroom and other places where floor drains are not present. Another positive feature of the water used in this presentation is the fact that it creates a large bulb at the bottom, unlike the beads that creep up to the top of the condom. This characteristic ensures that after the condom bursts the majority of the water is contained in a small area directly below the scale. This makes unwanted spills much less likely.

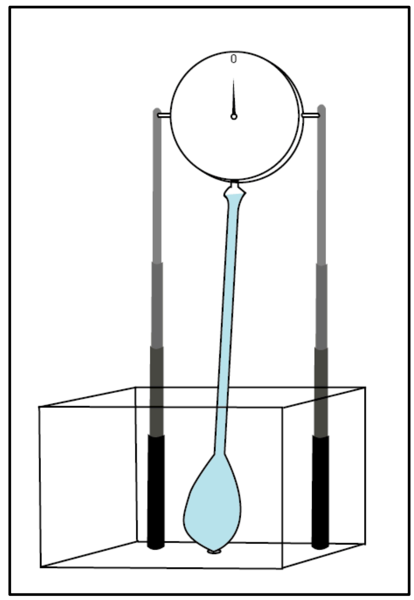


Figure 9. The demonstration mechanism using water weight.
Left: During the preliminary testing session, the team uses water instead of metal beads and receives an unexpected but impressive visual effect. Right: illustration of the water/dye design done by Jessica Kou.

4.1.3 Combination (Beads + Dye)

Our third proposal for a presentation mechanism is a combination of the first two. Again, the same basic mechanism would be used, with a scale attached to a funnel system, which is linked to a spout leading to a condom. The idea is to use some water and some beads. This would allow our client to still give the students an idea of how much weight was going into the condom with the beads, but still give the impressive effects of the water. It would also allow for the beads to be involved in the dye testing explained above which would lead to a more dramatic representation of the condoms strength. This combination might also cause problems however, as separating the beads from the water in the basin after the condom has burst may prove to be quite difficult and time consuming. Finding the perfect combination of beads and water is also a concern.

4.1.4 Free Fall

This final design proposal is completely different from the first three. It involves dropping metal rods of increasing weight into the condom until a rod with enough mass to generate enough force to break the condom is used. This type of action may be a more realistic representation of what actually happens to the condom during intercourse. It obviously would not put the exact same kind of stress on the condom, but it seems it would do a better job than water or beads at creating an appropriate imitation. A major problem with this design is that the force created by the three or four foot drop of a relatively small metal rod (one that can fit into a condom) may not be enough to actually ever break the condom. If this was the case, a motor of some sort would need to be built to shoot the rod. Building a motor may be well out of our price range.

4.2 Apparatus

The apparatus section deals with the general structure of the device, for example how the device will be carried, and what material will support the model. The two options in the apparatus section are *folding poles* and *telescoping poles*. Different collapsing methods of the poles play an important role in increasing the mobility of the entire device, as well as the adjustability of different heights of the device. In addition, both apparatus options will be integrated within a hand trolley for the purpose of mobility.

4.2.1 Folding Poles

Our first option in the apparatus section is using *folding poles* (Figure 10). To make the poles foldable, several joints are built to connect each segment of the pole together. Embedding this folding mechanism in the poles within our model can increase the transportability because it is easily folded into a compact space to carry. The first problem with this folding mechanism is that it is not variable enough in height during the presentation. Although adding more joints to the poles would add more adjustability, there is definitely a limit to how many joints could be added. In other words, the levels of adjustability would be discrete and not continuous.

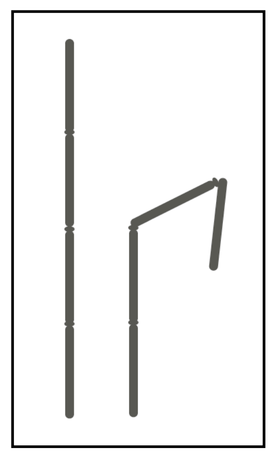


Figure 10. Folding Poles.
There are several joints connected along the poles to increase its adjustability (illustration by Jessica Kou).

4.2.2 Telescoping poles

Another option for the new model's apparatus is using *telescoping poles* as the supporting component (Figure 11). Shortening the poles using a telescoping mechanism would make operation easy, maintain high transportability when carrying, and also increase the adjustability to different heights. Unlike the aforementioned *folding poles,* the *telescoping poles* would allow for a continuous range of heights up to the maximum. A drawback of using this material will be the accessibility of such poles, and the weight of this type of poles is a subject to evaluation as well.

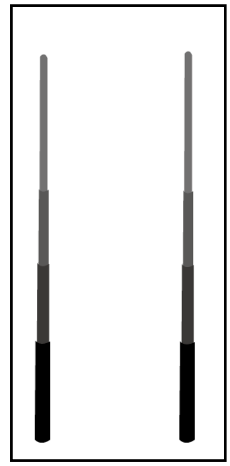


Figure 11. Telescoping Poles. The telescoping mechanism also allows for the adjustability of heights (illustration by Jessica Kou).

5.0 Design Matrices

During the design process, two design matrices were used to evaluate the two main categories, presentation mechanism and apparatus, separately. There are seven subcategories within the first matrix and three within the second matrix. A category's significance is made apparent by its numerical weight within the matrix. The weights were given by Dr. Marge Sutinen, the project client. Her preferences and opinions account for the degrees of importance on different categories.

5.1 Presentation Mechanism

Dr. Sutinen was able to rate the categories defined below in design matrix from most important to least important. As seen Table 2, She is most concerned with how easy it is to use the presentation mechanism. She would like the device to be easily operated by anyone, even without prior knowledge of the device. Dramatics also held a great deal of importance. This means it is important for the presentation to capture the audience. The students should be impressed by the strength of the condom after seeing the demonstration. Functionality was another key component in decision-making. The device must be able to perform whenever and wherever it is needed. It must also be consistent on every trial. The other four criteria are explained in the description of the design matrix and were also quite important. After rating each mechanism in each category a final score was tabulated. As seen in Table 2, the water weight design was chosen. The water weight mechanism will be further explored as the semester progresses because of its great dramatic display and its versatility.

Table 2. Design Matrix (I): Presentation Mechanism. This matrix consists of seven different categories and these categories were weighed by our client, Dr. Sutinen. Descriptions: Visibility: Can be seen from a long distance, Size: Small enough to be easily transported Cost: Possible to construct for under $100, Assembly/Disassembly Time: Time is takes for a person to set-up and dismantle the design.

Category	Pouring Beads	**Water Dye**	Combination (Beads + Water)	Free Fall
Ease of Use (25)	20	23	19	25
Dramatics (20)	17	**20**	18	10
Functionality (20)	15	20	15	15
Visibility (15)	13	14	13	10
Size (10)	10	7	7	5
Cost (5)	5	3	4	0
Assembly/Disassembly Time (5)	3	3	0	3
Total (100)	83	**90**	76	68

Ease of Use (25)

The free fall mechanism received the highest point total in this category because the user would only need to drop metal rods into the condom and clean up would be as easy as picking up the metal rod and broken condom. The water/dye mechanism scored higher than the either of the two bead mechanisms because water is easily replaceable and beads are not. That is, if the user misplaces the beads or loses them during a presentation then more will need to be purchased. However, more water can be found at the nearest drinking fountain. Finally, the combination design received the lowest points due to the fact that the separation of beads and water may be difficult for the user.

Dramatics (20)
This category's rankings were determined by the survey done in Dr. Sutinen's class. As previously mention, the students believe that water was more impressive than beads. Free fall received a lower score because the dramatics of this design are unknown.

Functionality (20)
The water/dye mechanism received the highest score because the water approach resulted in more consistent outcomes than the beads. During preliminary testing it was obviously that the beads caused the condom to break in a large range of weights and stretched lengths. That is, something about the beads made the condom's break point inconsistent. The water does a much better job of creating reproducible trials. Free fall again received a lower score because its consistency is unknown.

Visibility (15)
The larger bulb created during a water demonstration allows for greater visibility. The audience will be able to see the dyed water more clearly than beads from greater distances. The visibility of the free fall is assumed to be low due to the fact that the metal rods would not stretch the condom in the same fashion as the water or beads.

Size (10)
The pouring beads design takes this category because a tank of some sort would need to be created to contain a water-using device. This tank would definitely take up more space than the current device uses for catching the beads. Since a motor might need to be involved in the free fall mechanism, its size could be very large.

Cost (5)
The cost of the bead mechanism would be low due to the fact that the current device uses beads, and many of the parts that are currently used on that device could be recycled.

Assembly/Disassembly Time (5)
The combination design receives and extremely low score here, again due to the fact that separating beads from water may prove to be difficult.

5.2 Apparatus

Our apparatus matrix consists of three main categories: Ease of use, adjustability, and size. Table 3 shows the matrix and the tabulated scores for each of the two design options. Adjustability was defining category in this matrix, and the *telescoping poles* option appears to be the most effective.

Table 3. Design Matrix (II): Apparatus. There are three categories within the apparatus design matrix: Ease of Use, Adjustability, and Size. The *telescoping poles* earned more points mainly because of its higher adjustability.

Category	Folding Poles	**Telescoping Poles**
Ease of Use (50)	43	43
Adjustability (25)	15	**25**
Size (25)	25	20
Total (100)	83	**88**

Ease of Use (50)
The first and most highly weighed category in this matrix is ease of use. This refers to how easily it can be operated for average users. Since one of the design requirements is to allow everyone to access and operate this device, the ease of use tends to be the major concern to our client. Not only Dr. Sutinen will be performing the demonstration, but every student in her class will also need to perform the experiment. As a result, this category is given 50 out of the total 100 points. Both mechanisms were given the same score of 43 based on the fact that neither is completely self-explanatory, but both are relatively easy to use. This category's rating for either alternative may change based on a specific set of folding or telescoping poles.

Adjustability (25)
The second category in this matrix is adjustability. By adjustability, we mean the capability of the apparatus to move to different desired heights during the demonstration. Being adjustable is important in this model because during the preliminary testing, the team has found that different brands of condoms have various breaking points. The higher adjustability can prevent a case of unexpected breaking causing water or bead spills. For this category, the client gives a score of 25 out of the total 100. The *telescoping poles* are able to change height on a continuous range. This means that the height can be adjusted to extremely precise levels. The *folding poles* do not allow for nearly as much variability. As a result, the *telescoping poles* get a higher score in this category making it the defining category in the evaluation of the apparatus.

Size (25)
The last category in this matrix is the size of the poles. This category is included because it is an important concern regarding the transportability of the entire device. More precisely, highly condensable poles will allow for increased mobility of the device. For this category, our client gave 25 out of the total 100, making this category equally as important as adjustability. The *folding poles* received a higher score in this category because folding would allow a pole to reduce itself into a much smaller space than the

telescoping poles. This is due to the fact that the telescoping mechanism forces the poles to collapse into themselves, guaranteeing that taller poles will only be able to shrink into some fraction of their original height. Conversely, *folding poles* could possible lay flat while not in use.

6.0 Final Design

The final design incorporates the Water Dye presentation mechanism and the apparatus of the Telescoping Poles within a Hand Trolley. Furthermore, a draining system has been built in order to resolve the water-releasing problem. Figure 12 shows an illustration of the final design. In general, the overall structure will be similar to the current model built by the former BME students, but new ideas and improvements are added into the new model. In addition, the general procedure of the demonstration using this new model will be outlined and explained, as well as the different purposes and reasons for adding the new components into the final design.

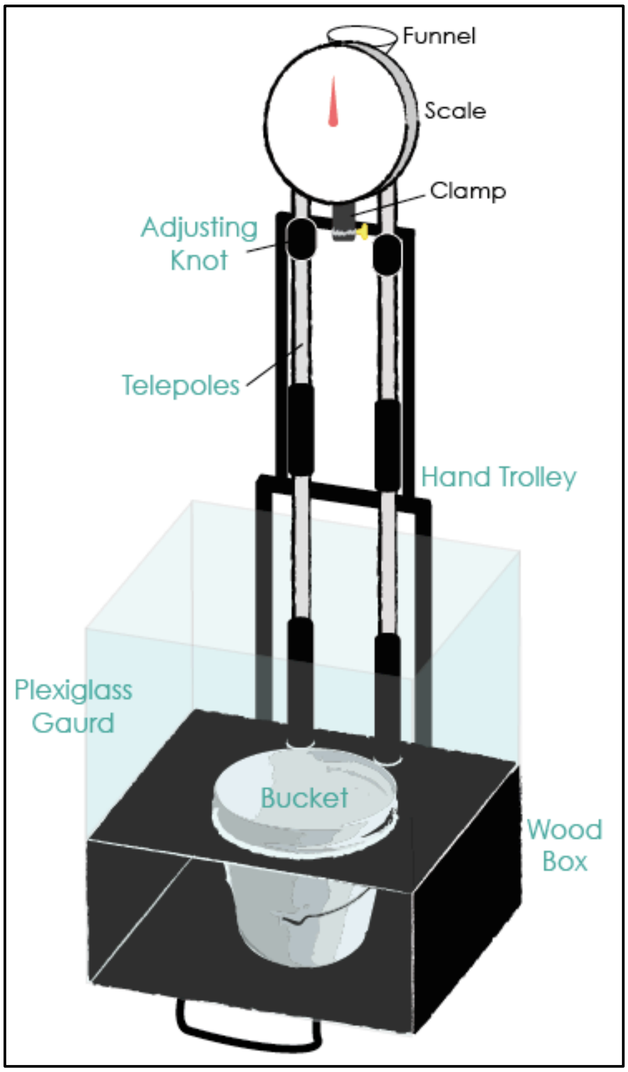


Figure 12. Final Design Apparatus.
The figure on the left is an illustration by Jessica Kou with labels on different features of the device. The picture on the right is the actual appearance of the new model.

6.1 Apparatus

6.1.1 Structures Overview

As shown in Figure 12 above, the device has several different features with various functions. First of all, the whole device is standing on a wood box foundation with a plexiglass guard surrounding it. There is a 2-gallon bucket embedded within the top piece of the wood box. The top surface of the wood box, the bucket, and the plexiglass together make the system for collecting water and preventing water splashes. The main support of the device is the two telescoping poles standing on the wood box base. The bases of the two poles are also embedded into the top piece of the wood box and the poles are removable since the poles can be unscrewed. Finally, the scale on this new model is reused from the previous model constructed by the former BME design team in the fall of 2009. (Detailed descriptions and explanation of each individual feature are provided in the following sections.)

6.1.2 Dimensions & Weights

One of the design criteria is to make the new device as light as possible and reduce the bulkiness for easier transportation. Figure 13 is the modified apparatus of the final design with dimensions labeled. The wood-box base is a rectangular box with the dimensions of 0.43m (length) × 0.33m (width) × 0.20m (height). The plexiglass then extends 0.34m (13.5in) from the top piece of wood. Furthermore, the telescoping poles can be extended up to a maximum height of 1.52m and can be adjusted for different stretching lengths of the condom and the different heights of the users. Our device weighs 7.35kg without the trolley, and 8.85 kg with the trolley.

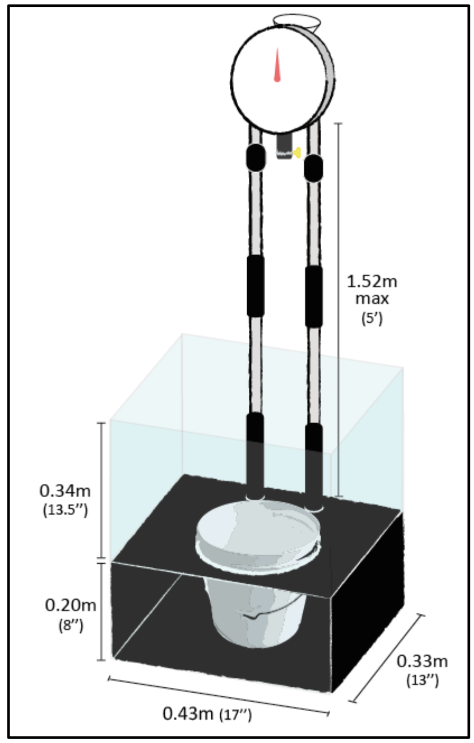


Figure 13. Final Design Apparatus with Dimensions labeled. The hand trolley is not included for the simplicity of the diagram. (Illustration by Jessica Kou)

6.1.3 Telescoping poles

The use of telescoping poles is one of the features and improvements that was added onto the new model. Referring to Figure 13, the two poles are standing on the top piece of the wood box and supporting the scale above. In order to prevent any tilting, the bases of the poles are embedded in the top wood piece and then supported on a middle platform in the wood box (see Figure 14, Back View). The two poles are 0.13m apart and this distance is fixed due to the design of the scale/pole attachment sites. There are two advantages using this particular type of pole. First, it is easy and smooth to readjust the height of the pole by loosening and tightening the pole locking mechanism (Figure 12). Another advantage is that the poles are removable from the wood box base. This removability of the poles allow for greater convenience for the client or other users to store the device into the trunk of a car for long-distance transportation. Also, when moving the device on the trolley or in hand, removing the poles might benefit users by making the apparatus less bulky.

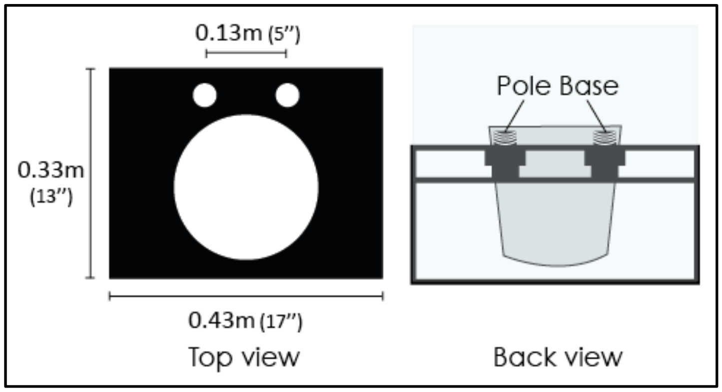


Figure 14. The top and back view of the wood box base. The top view (left) includes the dimensions of the top of the wood box. The back view (right) illustrates the embedment of the pole bases behind the bucket. (Illustration by Jessica Kou)

To confirm that the telescoping poles used in this model are strong enough to hold the water weight within the condoms, some static analysis is provided. A simple free body diagram is provided in Figure 15. Let the downward force (F) be the weight of the scale and the weight of the water filled in the condom. Assuming that the maximum weight that a condom can hold is 4.5 kg (10 lbs), and provided that the scale weighs 0.8 kg. Together the total downward force (F) is 51.993 N and we assume that this downward force is equally distributed on the two poles; thus one single pole will experience 25.996 N of force. The weight of one pole (W_{pole}) is 0.3 kg (0.65 lbs). The vertical reaction force (F_y) at the base will then be 28.94 N. And there is no horizontal reaction force (F_x) due to the geometry of the system. Given that the distance between the condom and the pole (x) is 0.02m. One can find the moments about point A. The moment (M_A) at the base joint is calculated to be 0.52N·m on each pole.

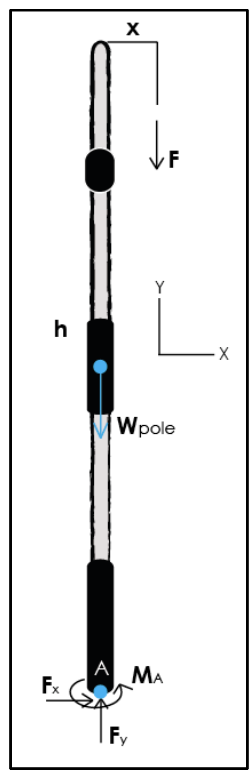


Figure 15. Free body diagram for a single pole. (Illustration by Jessica Kou)

The testing after fabrication process further confirms that the poles embedded into the wood box can support 4.5kg (10lbs) water. During testing, the LifeStyle condom was capable of holding 4.5kg (10lbs) of water, and the model was not damaged. In conclusion, the telescoping poles are strong enough for the demonstration purpose. (Detailed calculations can be found in Appendix 10.4)

6.1.4 Draining System

Once the team had made the final decision on using water as the presentation mechanism, incorporating a draining system into the device was the next step in the fabrication process. The team first thought about building a proper-sized and see-through tank that could be placed on the trolley and catch all the falling water when the condom reached its maximum capacity. However, several problems arose with this idea. First of all, the tank needed to be large enough to catch all of the water. However, the larger the tank the more difficult it becomes to pour the water out of the tank. Moreover, a large tank would be fragile and heavy, which would reduce the device's transportability. Where to install the poles and how to affix and carry the water tank on the trolley became the most important issues.

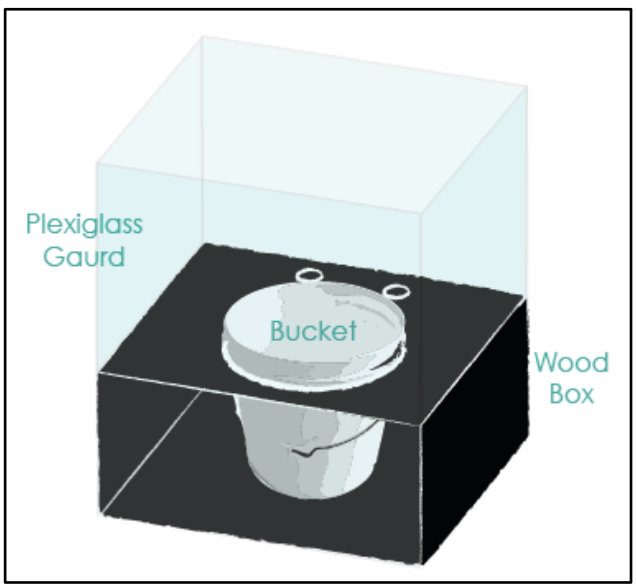


Figure 16. The draining system.
The wood box, the plexiglass, and the bucket compose the draining system of the device.
The figure on the left is an illustration by Jessica Kou, and the picture on the right is the actual appearance of the device taken after assembling the plexiglass and the wood box.

The team then designed a draining system that allowed for easy water removal but also prevented any excessive splashing. Referring to Figure 16, the black wood box serves as the base of the device that will sit on the trolley. On the top piece of the wood box, a hole was drilled to the exact size of the bucket diameter so that the bucket can be held but also removed. In order to reduce the weight of the device as much as possible, the wood box at the bottom is only composed of four pieces of wood, two on the sides and two on the top and the bottom. The remaining two sides are made of plexiglass. After building the wood box, black oil-based paint was used to coat the box to make it waterproof. To prevent water splashes when the condom bursts, a plexiglass guard was added onto the wood box with the height of 0.34m. To attach the plexiglass to the wood, *Loctite Stik'n Seal original Waterproof Adhesive* was used.

This draining system has several advantages. First of all, the overall model is easier to construct and it is more sturdy and stable, compared to a completely plexiglass water tank. Due to the budget constraints, the only material used to hold the plexiglass together is the glue. With more money, a more appropriate seal could have been made. The measurements and cuts needed to be extremely concise to reduce any leakage. Another advantage of this draining system is its ease of use. Removing a small bucket is far easier than the original idea of having to remove the water with a drainage spout; the bucket is small and easy to remove from the hole on the wood box. Additionally, pouring the water out of the bucket is an easy task.

On the other hand, there are some disadvantages that were not expected but were realized during testing (see section 7.0). Based on the demonstration performed in client's class, it was believed that the water should stay within the bucket during a presentation. However, the area for the water to fall into is smaller in the new design than the container used during preliminary testing (refer to Figure 6). As a result, the water actually splashed higher, which exceeded the height of the plexiglass guard on several occasions. Another issue with this draining system is that all of the water does not fall into the bucket, in other words, some water remains on the top piece of the wood box. An attempt to resolve this problem was made by drilling four holes on the edge of the bucket touching the top piece of the wood box so that the water could flow into the bucket. However, the water did not flow as expected because the holes on the wood box caused a break in the seal between the circumference of the bucket and the wood box. Thus, instead of flowing into the bucket, the water would drip into the gap between the wood box and the plastic bucket. This may cause a major inconvenience to the user, but as long as the leaks are minimal, the water will eventually dry due to the fact that the device is open to the air.

6.1.5 Hand Trolley

For the purpose of transportability, we chose to use a hand trolley for carrying the device. The Norris 200 80-Pound Capacity Multi-Purpose Folding Cart was chosen due to its low price (\$23.17) and its lightweight (1.5kg) (Figure 17). The capacity of this trolley is up to 36.3kg (80lbs), which is certainly capable of supporting the device. The dimensions of the platform are 0.34m (length) × 0.29m (width). Furthermore, this lightweight hand trolley can be folded up and stored easily if necessary. Lastly, the device is held tightly onto the trolley with the elastic band provided with the trolley.

Figure 17. Actual picture of the hand trolley
(Adapted from pictures posted on Amazon.com, 2010)

6.2 <u>Demonstration Procedure</u>

Begin the demonstration by making sure that the hand trolley base is fully open. Then, set the wood box on the trolley base. Both pole attachments inside the box should be located on the side of the trolley with the hand grips. It is important to make sure the box is secure on the trolley and will not move around. This can be ensured by placing the elastic strap around both the wood base box and poles of the trolley. The bucket should then be placed inside the hole in the center of the black wood box. The two telescoping poles can then be twisted into the pole bases. The scale can then be slid into position with the numbers facing the bucket. At this point, the model is fully set up for demonstration.

The telescoping poles can then be set at a height where the funnel is at a reasonable height for the user. A condom can then be unrolled and clamped to the black spout below the scale. Next, water can be poured slowly into the funnel. When the scale reads 5 pounds, the demonstrator should carefully loosen the telescoping poles and lower the apparatus down until the condom is 5 to 8 centimeters away from the bottom of the bucket. Then tighten the poles again. This is done to ensure the water is contained in the water tank and bucket. The higher up the condom is, the larger the splash. If it is too high, all the water might not be contained. It is believed that at 5 pounds the condom has reached it maximum stretching distance both in height and width. The students will have already seen the stretching capacity of a condom by this point. The demonstration can then be continued by pouring more water in the condom until it breaks. Some students may not be able to see the condom at this point, but they will still see the scale display the weight of the condom. This will allow them to continue to learn about the condom's strength.

After the condom has broken, almost all of the water will be in the bucket. The bucket can then be removed and the water discarded. There may be some water still in either of the two levels of the wood box. This should be a very tiny amount and can just be aired dried. The telescoping poles can then be lowered all the way back down and the bucket replaced. The device can then be left as is and transported this way.

6.3 <u>Summary</u>

Table 4 shows a list of the requirements and expectations from our client (left column), and how we solved each problem and concern within the final design (right column). To provide a more dramatic and effective demonstration to the audience, we choose to replace the beads with water or dyed water, which has been evaluated through the first matrix and the demonstration in the client's class. To maintain a higher level transportability, the model will be carried by a hand trolley. Its lighter overall weight comparing with the previous device has certainly increased the transportability as well (Table 5). Although the device is 1.25kg heavier than the old model without the trolley, removing the two poles (0.6kg) and the scale (0.8kg) can reduce the weight down to 5.95kg, which is therefore lighter than the previous device (6.1kg). Using water as the presentation mechanism is one of the strategies of reducing the device weight because the metal beads used for the old model is the main source of the heavy weight.

The device can be removable for several purposes such as carrying it up stairs and adapting to different teaching environments. The model is built to be a one-piece design to reduce the time of installation, but the poles and the scales are still removable if needed for transportation or other purposes. It was first thought that the adjustability of the telescoping poles was to solve the issue of different breaking point of different brands of condoms. However, using water appears to have the similar stretching length to all the brands that we have tested. Generally the condoms will extend all the way down to the draining-system guard, or surrounded by the plexiglass. Therefore, the adjustability will function to adapt to the different heights of the users. As described in section 6.2, the user can first adjust the device to the height that he/she feels most comfortable with. After reaching 2.27 kg of water, the user can readjust the poles again so that the bottom part of the condom is slightly touching the bottom of the bucket. Lastly, if the water source is not available, the original method of pouring metal beads is still welcome to be used since the new model is adopting a similar design to the original.

Table 4. Summary of requirements and expectations with corresponding solutions in the final design. The left column is the list of requirements, expectations, or concerns arising throughout the design process. The right column provides the corresponding solutions to each requirement.

Requirements & Expectations	Features
More Dramatic Demonstration	Water
Higher Transportability	Hand Trolley + Removable Device Lighter weight
Time consuming installation	One-Piece Model
Water-Splashing Problem	Plexiglass Guard
Water-Releasing Problem	Draining System
Adaptability to Different Environments	Standing/Table Model
Various Breaking Points & User's Height	Telescoping Poles
If Water is Not Available	Original Presentation Mechanism Applicable

Table 5. Weight comparison between the old and new model.
The measurements are taken for both the without-trolley condition and with-trolley condition

Model	Without Trolley (kg)	With Trolley (kg)
Spring 2009 Model	6.1	9.15
Fall 2010 Model	7.35	8.85

6.4 Budget Analysis

Table 6. List of the items that were purchased for model construction.
(* indicates that the wood board is free from the Engineering Center Building workshop)

Item Name	Price ($)
Norris 200 80-pound Capacity Multi-Purpose Folding Cart	23.17
100% Silicone Sealant from General Electric Company	5.97
Titebond II Premium Wood Glue	4.19
Loctite Stik'n Seal original waterproof adhesive	4.89
Total-Reach 5' telescoping Poles (2 poles)	27.41
36*48 plexiglass	24.97
2 gallon bucket	4.32
Rust-Oleum protective enamel	10.13
Wood board	0*
Total	**105.05**

6.5 Time Management

Table 7. The time line of the project throughout the semester.

Tasks	September				October					November				December	
	3	10	17	24	1	8	15	22	29	5	12	19	26	3	10
Research	X	X	X	X	X			X	X	X	X	X			
Brainstorming	X	X	X	X	X							X	X		
PDS		X				X								X	
Prototype Design													X		
Prototype Fabrication													X	X	
Testing				X						X				X	
Meeting with Client	X			X						X					
Team Meeting	X	X	X	X	X	X	X		X	X	X		X	X	
Presentation						X								X	X
Written Reports							X							X	X
Peer/Self Evaluations								X							X

7.0 Testing

After the fabrication of our model was complete, the device was tested as it would be used in a regular demonstration. Multiple condoms were filled with water and showed the same consistency as was apparent in the preliminary testing (see Table 7). The Average stretch length was 101.6 cm and the average holding weight was 3.52 kg. One condom even held a weight of greater than 4.54 kilograms. One problem that occurred during testing was the splashing of the water. Our design had the water release point a bit higher than the previous model. This created a greater splashing effect and all the water was not contained. It was determined, however, that filling the condom to about 2.27 kg would allow the students to fully experience the intended effect before the condom actually broke. And at that point the poles could be lowered so that the bucket/plexiglass guards could contain the splash more effectively. This procedure would maintain the integrity of the presentation and also keep the water self-contained. Further trials proved this to be correct.

Table 8. Four different brands of condoms and their capacities.
The capacity indicates the maximum weight that each condom can hold.

Brand	Color	Lubrication	Capacity
Altas	Clear	Yes	3.52 kg (7.75 lbs)
Lifestyle	Strawberry pink	Yes	4.65 kg (10.25 lbs)
Trustexd	Dual-Color Tip: Green Base: Orange	Yes	3.52 kg (7.75 lbs)
Fantasy	Yellow banana-flavored	Yes	1.70 kg (3.75 lbs)

Current Inter-engineering 160 lab students were also working on their projects while we were testing. We asked some of them to watch our demonstration and provide input on the model. These students were shocked and surprised that a condom could hold so much weight. The ballooning of the condom was also impressive to them. One student even thought we were tricking them and using water balloons and not condoms. This feedback gave the group the impression that the demonstration provided the desired effect.

Figure 18. A Picture of testing the Trustexd condom.

8.0 Future Work

8.1 Achievements vs. Improvements

There are several improvements that could be made to improve the quality of our device. First of all, the draining system that we currently have is not perfectly designed. If the operator failed to use the device correctly, it may cause some minor problems such as water splashing. A more careful construction would resolve these problems. A larger budget would have allowed for better water containment.

Second, the overall weight of the device is not as light as desired. Reducing the materials we used may be a solution to this problem. However, a lot of testing, especially testing on the device's mechanical properties should be done so that we know which part of the device could be replaced by other materials. Again, this problem would also be tied with the draining system used and the budget constrain.

Compared to the previous model, our device is easier to transport because our model is a one-piece design. This makes it easier to carry because instead of having many separated parts to transport like the old model, a one-piece design makes the whole device more compact for transportation. However, our current design is a little too bulky to carry with hands. This would be a problem if the operator had to carry it up stairs. Possible solutions include using materials that are more compact but still sturdy enough for the whole structure (such as metal), or using more advanced techniques to fabricate the device.

8.2 Action on World AIDS Day

World AIDS Day (December 1) was first conceived in August 1987 by James W. Bunn and Thomas Netter, two public information officers for the Global Program on AIDS at the World Health Organization (WHO) in Geneva, Switzerland (World AIDS Day, 2010). In order to raise the awareness of the HIV diseases across the world, taking some actions is encouraged in different countries across the world. For example, Chi-Liang Yang, the director of the Department of Health in Taiwan took an action on November 30, 2010. Due to the rapid growing population of the age of 15 to 24 getting AIDS in Taiwan, he dispatched hundreds of condoms to some popular nightclubs in Taipei and explained the importance of safer sex and the prevention of HIV diseases (Lee, 2010). The idea of promoting safer sex is the ultimate goal of our device as well. Therefore, we suggest that demonstrating the strength of the condoms using our model at least once a year on campus, especially around the World AIDS Day, would be effective in raising the awareness of AIDS. Our device and the presentation mechanism are found to be effective based on the reactions from the students in the client's class. Currently only the students that are taking the client's class have seen our demonstration. If possible, we hope that other courses would include such s demonstration in class and spread the idea of safer sex.

9.0 References

Balge, N., Cheadle J., Gahlman, T., & Johnson, W. (2009). Male Barrier Demonstration Apparatus. *Biomedical Engineering Department, Poster Presentation*.

Lee, H. J (2010). Yahoo News, Taiwan. http://udn.com/NEWS/NATIONAL/NAT5/6003012.shtml. Accessed on December 7, 2010.

National Institute of Allergy and Infectious Disease. 2004 http://www.niaid.nih.gov/Pages/default.aspx. Accessed on December 3, 2010.

Norris (2010). Norris 200 80-Pound Capacity Multi-Purpose Folding Cart. http://www.amazon.com/gp/product/B0032FPIB6/ref=oss_product. Accessed on December 4, 2010.

Pease, C. M. & Bull, J. J. (2000). Models of sex in condom testing. http://www.utexas.edu/courses/bio310d/Topics/Condoms/Text.html.

Schellstede, William P., Eli J. Carter and William R. Finger. 2010. http://www.fhi.org/en/RH/Pubs/booksReports/latexcondom/standspectests.htm. Family Health International. Accessed on December 4, 2010.

Weller S, Davis K. 2002. Condom Effectiveness in Reducing Heterosexual HIV Transmission. Preventative Medicine, University of Texas Medical Branch.

10.0 Appendix

10.1 Preliminary Testing Data

Brand	Weight (lbs)	Length (in)	Elongation (in)	
LifeStyle	0	8	0	
	1	21	13	
	2 ¼	38	17	break
Durex	0	10	0	
	1	19	9	
	1 ½	22	3	break
Fantasy (strawberry)	0	8	0	
	½	11	3	
	1	15	4	
	1 ½	19	4	
	2 1/8	24	5	
	2 ½	28	4	
	3	30	2	
	3 ½	36	6	
	4	38	2	break

10.2 Survey on Demonstration

HIV Barrier Presentation Survey

Prior to presentation:

1) Do you or your partner use condoms?

2) If not, why don't you?

   A) You usually don't have one on hand.
   B) You don't want to bring it up to your partner.
   C) You don't trust the condom's quality.
   D) You are not worried about the consequences of sexually transmitted diseases.
   E) Or state another reason below.

3) Is the strength of a condom an issue for you?

After the presentation:

4) If you do not usually use condoms, did the presentation change opinion on condom use?

5) Are you more likely to keep a supply of condoms on hand?

6) Did the presentation improve your confidence in the strength of condoms?

7) Will the experience of the presentation allow you to talk with a partner more easily about condom use?

8) Which presentation water or beads, was more impressive/dramatic?

10.3 Statistical Results of the Survey by Client's Class

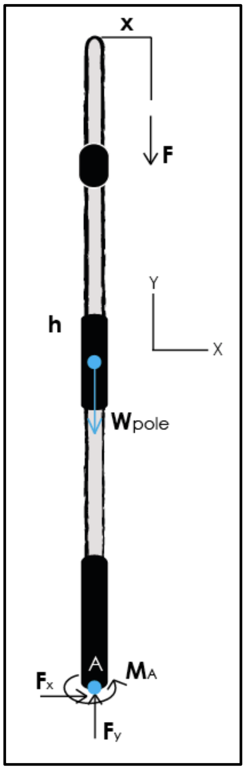
	#1			#2			
Sample #	Yes	No	Sometimes	A	B	C	D
1	0	0	1	0	0	0	0
2	0	1	0	0	0	0	0
3	1	0	0	0	0	0	0
4	1	0	0	0	0	0	0
5	1	0	0	0	0	0	0
6	0	1	0	0	0	0	0
7	0	1	0	0	0	0	0
8	0	1	0	0	0	0	0
9	1	0	0	0	0	0	0
10	1	0	0	0	0	0	0
11	0	0	1	0	0	0	0
12	1	0	0	0	0	0	0
13	1	0	0	0	0	0	0
14	0	0	1	0	0	0	0
15	1	0	0	0	0	0	0
16	1	0	0	0	0	0	0
17	1	0	0	0	0	0	0
18	1	0	0	0	0	0	0
19	1	0	0	0	0	0	0
20	0	1	0	0	0	0	0
21	0	1	0	0	0	0	0
22	0	0	1	1	0	0	1
23	1	0	0	0	0	0	0
24	0	0	1	0	0	0	1
25	0	0	1	1	0	0	0
26	1	0	0	0	0	0	0
27	1	0	0	0	0	0	0
28	0	0	1	0	0	0	0
29	1	0	0	0	0	0	0
30	1	0	0	0	0	0	0
31	1	0	0	0	0	0	0
32	1	0	0	0	0	0	0
33	1	0	0	0	0	0	0
34	1	0	0	0	0	0	0
35	1	0	0	0	0	0	0
Total	22	6	7	2	0	0	2
Stats	62.86%	17.14%	20.00%	15.38%	0.00%	0.00%	15.38%
	#1			#2			
	Yes	No	Sometimes	A	B	C	D

			#3		#4		#5
Birth control	Trust partner	Other	Yes	No	Yes	No	Yes
1	0	0	0	1	1	0	1
1	1	0	0	1	0	1	1
0	0	0	1	0	1	0	1
0	0	0	0	1	0	1	0
0	0	0	0	1	0	1	0
0	1	0	1	0	0	1	1
0	0	1	0	1	0	1	0
0	0	1	0	1	0	1	0
0	0	0	0	1	1	0	1
0	0	0	0	1	1	0	0
0	1	0	0	1	1	0	1
0	0	0	0	1	1	0	1
0	0	0	0	1	1	0	1
0	0	1	0	1	0	1	1
0	0	0	1	0	1	0	1
0	0	0	0	1	0	1	1
0	0	0	0	1	0	1	1
0	0	0	0	1	0	1	1
0	0	0	0	1	0	1	0
1	1	0	0	1	0	1	0
1	1	0	0	1	0	1	0
0	1	0	0	1	1	0	1
0	0	0	0	1	1	0	1
0	1	0	0	1	0	1	0
1	1	0	1	0	0	1	1
0	0	0	0	1	1	0	1
0	0	0	0	1	1	0	1
0	0	1	0	1	0	1	0
0	0	0	1	0	1	0	1
0	0	0	0	1	1	0	1
0	0	0	0	1	0	1	0
0	0	0	0	1	1	0	1
0	0	0	0	1	0	1	1
0	0	0	0	1	0	1	0
0	0	0	0	1	1	0	0
5	8	4	5	30	16	19	22
38.46%	61.54%	30.77%	14.29%	85.71%	45.71%	54.29%	62.86%
			#3		#4		#5
Birth control	Trust partner	Other	Yes	No	Yes	No	Yes

	#6		#7		#8	
No	Yes	No	Yes	No	Water	Beads
0	1	0	0	1	1	0
0	1	0	1	0	1	0
0	1	0	1	0	1	0
1	1	0	0	1	1	0
1	1	0	0	1	1	0
0	1	0	0	1	0	1
1	1	0	0	1	1	0
1	0	1	0	1	0	1
0	1	0	1	0	1	0
1	1	0	1	0	1	0
0	1	0	1	0	1	0
0	1	0	1	0	1	0
0	1	0	1	0	1	0
0	1	0	1	0	1	0
0	1	0	1	0	1	0
0	1	0	0	1	1	0
0	1	0	0	1	1	0
0	1	0	0	1	1	0
1	1	0	1	0	1	0
1	0	1	0	1	1	0
1	1	0	1	0	1	0
0	1	0	1	0	1	0
0	1	0	1	0	1	0
1	1	0	1	0	1	0
0	0	1	1	0	1	0
0	1	0	1	0	1	0
0	1	0	1	0	1	0
1	1	0	1	0	1	0
0	1	0	1	0	1	0
0	1	0	0	1	1	0
1	0	1	0	1	1	0
0	1	0	1	0	1	0
0	1	0	0	1	0	1
1	1	0	0	1	0	1
1	1	0	1	0	1	0
13	31	4	21	14	31	4
37.14%	88.57%	11.43%	60.00%	40.00%	88.57%	11.43%
	#6		#7		#8	
No	Yes	No	Yes	No	Water	Beads

10.4 Calculations of the Static Analysis on Telescoping Poles

Known: $X = 0.02$ m, $W_{pole} = 0.65$ lbs, water = 4.5 kg, scale = 0.8 kg



$$\sum Fx = 0\text{: } -F_x = 0 \rightarrow F_x = 0$$
$$\sum Fy = 0\text{: } -F - W_{pole} + F_y = 0 \rightarrow F_y = F + W_{pole}$$
$$\sum M_A = 0\text{: } F \times X - M_A = 0 \rightarrow M_A = F \times X$$

$F = (4.5 \text{ kg} + 0.8 \text{ kg}) \times 9.81 \text{ m/s}^2 \div 2 = 25.996 \text{ N}$
$W_{pole} = 0.65 \text{ lbs} = 0.3 \text{ kg} \times 9.81 \text{ m/s}^2 = 2.943 \text{ N}$
$F_y = F + W_{pole} = 25.996 \text{ N} + 2.943 \text{ N} = 28.939\text{N}$
$M_A = F \times X = 25.996 \text{ N} \times 0.02 \text{ m} = 0.52 \text{ N}\cdot\text{m}$

10.5 Product Design Specifications

HIV Barrier Model – Product Design Specifications

Leader: Wan-Ting Kou
Communicator: Bret Olson
BSAC: Albert Wang
BWIG: Lisle Blackbourn

Problem Statement

To demonstrate the strength and durability of latex and polyurethane barriers against HIV infection and other sexually transmitted infections. Currently the original version developed by former BME students has been received extremely well by client's classes in the medical genetics course "Contemporary Issues on HIV/AIDS", however, the model is fragile and not easily transportable. The client is requesting an improved more sturdy and mobile product.

Client Requirements

- Client would like the device to be more mobile.
- A more user friendly version of the current model
  - Lightweight
  - Less parts
  - Easy to install
  - Less bulky
  - Make parts more easily replaceable
  - Sturdy
- Inexpensive (<$100)
- The product must demonstrate the strength and effectiveness of condoms.
- Make a product that is easily reproducible.

Design Requirements

1. **Physical and Operational Characteristics**
   a. *Performance requirements*:
   The design would be used as a class and take home demonstration device. This means that it could be used five to ten times a semester. Our design would need to be capable of functioning properly on each of these occasions. To function properly our design needs to be self-contained; after uses there should not be any water or condom material left behind. The device should serve its purpose meaning that the display should capture the audience and teach them about condom strength.
   b. *Safety*:
   Our design needs to protect the operator from any harm while demonstrating its function. Furthermore, we may need to consider the possibility of small parts falling from the device and causing problems. If the device fails to contain any water, this may cause a slipping hazard to students. Users should be aware of this and clean up any spills.

c. *Accuracy and Reliability*:
Ideally our product would be 100% reliable, meaning it would perform its function on every occasion. The device also needs to be reliable for any of the variety of condoms available to consumer. This means the device needs to be adjustable in height. The accuracy of the scale involved in our design is very important because this measurement is what demonstrates the strength of the condom. Specific directions should be given to anyone who is going to perform a demonstration. This will allow for consistent and productive demonstrations.

d. *Life in Service*:
This device must be reusable. Although this device may only be used 5 to 10 times every 6 months it should be able to perform at any time if necessary.

e. *Shelf Life*:
The shelf life would depend on a number of things including, the calibration of the scale, and the wear of parts or the misplacement of any parts. We would expect that with proper maintenance our product would last upwards of 10 years.

f. *Operating Environment*:
Our device would be used in classrooms, or other presentation venues. This does not mean that our device should only work in these places. It should be capable of performing on any flat surface.

g. *Ergonomics*:
The device must be extremely user friendly. Anyone who is at least 1.6 meters tall should be able to operate the device with ease. It is also important that the audience understands the mechanism, so that the durability of the condom can be portrayed.

h. *Size*:
The device must be large enough so that someone sitting 20 meters (furthest distances in a regular classroom) away could see the results of the experiment. It must also be able to fold up in some fashion so that it would be easily transportable or stored.

i. *Weight*:
The device would need to be light enough so that anyone capable of using it would be able to transport it. We believe that 7 kilograms is light enough for anyone capable of using the device.

j. *Materials*:
The materials used would need to be somewhat aesthetically pleasing considering our device would be used as a presentation device. The materials must also be durable because the device would need to stay intact for many years.

k. *Aesthetics*, *Appearance, and Finish*:
The device's appearance is actually quite important because it is being used as a presentation device. The device's materials would also need to be water resistant in order to prevent it from decaying rapidly.

2. Production Characteristics

a. *Quantity*: 1 deliverable.
b. *Target Product Cost*: Under $100

3. Miscellaneous

a. *Standards and Specifications*: N/A
b. *Customer/Patient related concerns*: N/A
c. *Competition*: As far as we know there are not any devices like this besides the previous BME design group product.