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TEAM #36: PORTABLE CERVICAL CANCER SCREENING TABLE

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ABSTRACT

Cervical cancer is the leading cause of cancer death for Peruvian women. One of the main contributors to this situation is the lack of easily accessible examinations for a large portion of the indigenous population within the country. To tackle this, organizations such as our client, CerviCusco, are providing free checkups and pap-smears for women by traveling, and backpacking through Andean trails to access to deliver high-quality medical care. In order to assist their efforts our team is creating a portable, lightweight, and fully functional cervical cancer examination table for the CerviCusco doctors and volunteers. Our main point of contact within the organization is Dr. Darron Ferris the founder of CerviCusco and our Virginia Tech faculty sponsor is Dr. Kevin Kochersberger. The team itself consists of mechanical engineering seniors Vishal Sangam, Syd Ulrich-Dogonniuck, Marshall Rice, Maunesh Patel, and Linda Kim.

At its current stage the team has fully completed the client's needs and its goals for the design project. First, the team evaluated the client's needs and linked them to measurable targets. After, background research was conducted on current medical support devices used in practice by medical professionals. Next, preliminary concepts were generated by the team and revised by all key stakeholders. Finally, the team completed final concept, the build and testing. Currently the team is planning to travel along with the sponsor to Peru on May 16, 2017, to present and implement the product at CerviCusco's main facility in Cusco, Peru.

INTRODUCTION

CerviCusco was established in 2008 with the primary goal of spreading awareness for cervical cancer, as well as developing better methods for prevention than are currently available in the remote and impoverished regions that are common throughout Peru. This is an extremely important topic in the medical field with regard to Peru as cervical cancer is the leading cause of cancer deaths among Peruvian women. A majority of the area directly surrounding the city of Cusco, Peru, is in a highly mountainous region which poses multiple problems for both the CerviCusco doctors and the Peruvian women in the area. As these areas are very impoverished, many of the women in the associated area are not aware that cervical cancer is an issue. Thus they have never been screened nor are they aware that a cervical screening would be beneficial. Additionally, for many of these women to get to the CerviCusco facility in Cusco it would require them to take multiple busses and/or hike through mountainous regions for hours--an ordeal not many women are willing to do for a screening they don't even fully understand.

CerviCusco as an organization also experiences similar issues--they host clinics almost every month in different locations in the area around Cusco however many of these locations are difficult to reach. They frequently take a van as far as possible and then backpack all their supplies to the final destination. These supplies usually include a tent to set up with, two tables, small stools for the doctors, and all the medical supplies they may need for a 2- or 3-day clinic on hundreds of women.

CerviCusco has performed over 50,000 screenings since it opened in 2008 and intends to grow this number in the next few years. Hopefully by 2018 CerviCusco will be able to perform 22,500 screenings annually, thus reaching 80% of the base female population of Peru. In order to do so, however, CerviCusco needs to create more effective methods of performing clinics in remote regions. To reach this goal, CerviCusco also needs to be able to reach other locations that are currently too remote to access with the amount of medical supplies they carry in at present.

In order to access these remote regions, CerviCusco reached out to Dr. Kochersberger with the idea of creating a lightweight, portable cervical cancer screening table. Thus, for this project we will be working to create a solution for CerviCusco to increase the accessibility of these remote, mountainous regions around Cusco and support CerviCusco in providing high quality, much needed medical attention to the women of Peru.

BACKGROUND

First and foremost it is important to understand CerviCusco, the project sponsor. CerviCusco is a non-profit organization that is committed to decreasing the rates of cervical cancer in Peruvian women in the greater Cusco region. As Peruvian women have the highest rate of death due to cervical cancer in the world, it is important that as many women as possible are tested and treated accordingly. However, due to a lack of resources coupled with a lack of information regarding the possibilities of cervical cancer, many of the women who should have regular PAP-smear tests or other check-ups are not aware of such concerns.

In order to combat both of these issues, CerviCusco performs free clinics for women in the city of Cusco as well as many of the smaller towns surrounding Cusco. During these clinics, medical personnel examine hundreds of women and the practice uses a “treat-on-sight” method to ensure that all the women treated are released from the clinic in the best health possible. Additionally, CerviCusco provides pamphlets and information in both Spanish and Quechua, the indigenous language of the region, regarding regular screenings and daily feminine health concerns.

Due to the lack of resources in many of the smaller towns where CerviCusco holds clinics there are frequently no medical service buildings, thus impromptu screening tables or tables are used that are uncomfortable for the patients, doctors, or both. Thus, to help CerviCusco execute successful clinics in remote locations, a design and prototype of a portable table or table for cervical cancer screenings were requested of Team 36 at Virginia Tech.

Though there are other portable medical tables, the needs of CerviCusco proved singular due to the specific positioning of each patient required during cervical cancer screenings dependent on the age of the patient and the procedure being performed. Additionally, a lack of infrastructure in the more remote regions of the Andes Mountains meant that the final product needed to be lightweight enough to carry or backpack over rugged terrain for up to a few hours as the clinic personnel hiked to each location. So though there were other lightweight, portable medical screening-type tables, this design proved unique in that the product needed to fit directly into a backpack or equivalently shaped bag, and have weight-bearing, adjustable stirrups as they help align the patient’s cervix at the correct angle for screenings.

As a result of being one of the first designs to fit the need faced by CerviCusco, the only designs that influenced the final product made by Team 36 were portable dental tables used by clinics in developing nations. Although the designs all proved portable, due to the specific patient position required by CerviCusco the overall designs of the portable dental tables did not prove to be as beneficial as was originally thought.

REQUIREMENTS AND SPECIFICATIONS

In order to design and build a device that would adequately serve as a cervical cancer screening table, a set of customer needs was developed and the associated engineering specifications were decided upon based on the relative weight of each need. To come up with the list of customer needs, the team met with Dr. Kochersberger, the Virginia Tech faculty advisor, had multiple skype meetings with Dr. Ferris, a gynecologist and one of the founders of CerviCusco, and visited the practice of Dr. Gustavson, a local gynecologist at the LewisGale Medical Center in Roanoke, VA. The following list of customer needs was developed as a result:

Easily portable. The final product will be carried over rough terrain to remote clinic sites, thus the product must be as ergonomic as possible for the person transporting the product.

Lightweight. Again, due to the manner in which this product will be used, the ability to use the product as intended requires that it be easy to get the product on-site, thus minimizing the total weight of the product is of importance.

Doctor’s stool is a necessary component. Due to the specific dimensions of the screening table, the doctor must be at a specific position as well to easily and comfortably conduct screenings. As is unlikely a small table or stool always be available in remote locations, a small stool for medical personnel is required.

Proper patient position. To accommodate women of different ages as well as the positions required during different procedures, the product must have the ability to be set at different angles.

Durable. Frequent handling by multiple people means that durability is a must.

Easy to clean. As medical procedures will be conducted on this product, it must be made of materials that can be cleaned easily to prevent the transmission of bodily fluids.

Non-corrosive. There is the possibility that the product will be transported through inclement weather, therefore the use of non-corrosive materials would be recommended.

Extended product lifetime. The team at CerviCusco does approximately one clinic in a remote region every month, and at each of these clinics as many as a few hundred women are treated. Though this idea is linked to the durability, an extended product lifetime is more related to the durability and stress thresholds of any hinges and pins in the product.

Intuitive setup and breakdown. The product will be assembled and disassembled very frequently, and possibly by different people each time, thus the setup and breakdown should be straightforward.

Strong, moderate and weak correlations were then drawn between the customer needs listed above and a set of target specifications in order to create measureable units for the needs discussed. The target specifications that were created are listed below in order of weighted importance (absolute scores based on correlations given in parenthesis):

Ergonomic design (141)
Coating/material (84)
Drop height (69)
Articulating motion (60)
Minimal number of separate parts (55)
Material porosity (51)
Modular (45)
Number of uses (42)
Weight (41)

The relationship between each target specification and its ranking was calculated using Table 1, below.

Table 1. Customer Needs and Associated Target Specifications with Absolute Scores

ENGINEERING CHARACTERISTICS												
				1	2	3	4	5	6	7	8	9
			Cust. Weight (1-5)	Ergonomic Design	Weight	Modular	Minimal # of Seperate Parts	Articulating Motion	Drop Height	Material Porosity	Coating/Material	Number of Uses
Customer Needs	1	Easily portable	5	9	3				3			
	2	Less than 10 lbs	1	3	9		1				3	
	3	Doctor's Stool--Necessary	4	3	3	9	3					
	4	Proper patient position	5	9				9				
	5	Durable	5		1		3		9		3	3
	6	Easy to clean	5							9	9	
	7	Non-corrosive	2							3	9	
	8	Extended product lifetime/life expectancy	3						3		1	9
	9	Intuitive Setup and Breakdown	3			3	9	1				
	10	Accommodates patients with limited mobility	4	9				3				
		Absolute Score		141	41	45	55	60	69	51	84	42
9 = strong correlation, 3 = moderate correlation, 1 = weak correlation												

The metrics that will be used to assess the final design can be found below in Table 2.

Table 2. Target Specifications with Marginal and Ideal Values

Target Specifications Table					
Need(s)	**Metrics**	**Importance**	**Units**	**Maximum Marginal Value**	**Maximum Ideal Value**
1,2,3,4,9	Ergonomic Design	1	Scale 1-10	7	10
2,5,6,7,8	Coating/Material	2	Pass/Fail	Pass: Chair needs to be wiped down and dry with sterile solution with some effort	Pass: Chair needs to be wiped down completely without any remaining solution
1,5,8	Drop Height	3	ft	2	3
4,9,10	Articulating Motion	4	Degrees	0-45	0-90
2,3,5,9	Minimal # of Separate Parts	5	Number of Parts	15	8
6,7	Material Porosity	6	Pass/Fail	Pass: Chair needs to be wiped down and dry with sterile solution with some effort	Pass: Chair needs to be wiped down completely without any remaining solution
3,9	Modular	7	Pass/Fail	Includes provider chair only	Includes provider's chair and stool/seat for the doctor
5,8	Number of Uses	8	Uses	3600	9000
1,2,3,5	Weight	9	lbs	20	10

Most of the metrics are easy to understand, however a few of the marginal and ideal values should be explained in further detail for clarity.

Ergonomic design. This metric will be measured using a set of surveys for ergonomics and patient comfort. To pass marginally, the responses must be at least 70% positive, however of course 100% positive feedback would be the ideal response.

Articulating motion. As most of the medical procedures require the patient's back to be angled between flat and a 45 degree angle, that range constitutes the marginal limit. However, it would be useful if the screening table could convert into an upright position with the back support perpendicular to the seat for times when the doctor simply wants to explain the procedure to a patient.

Number of uses. The marginal and ideal values for the number of uses were calculated assuming an average of 150 women treated per clinic, 1 clinic per month on average and life expectancy of 2 years and 5 years, respectively. This resulted in a marginal value of 3600 uses and an idea value of 9000 uses.

ANALYTICAL RESULTS

Any existence of irregularities or discontinuities in a design alters the stress distribution and increases the theoretical stresses significantly in the immediate vicinity of the discontinuity. Therefore, in this final design, the bottom leg carbon fiber tube members with the reinforced holes for pin locking were speculated as an area where failure was most likely to occur with loaded bending stress of a patient's proposed 20 pound body weight.

Thus, to evaluate the factor of safety of this area the effect of stress concentrations near the hole discontinuity was considered. Appendix Table A-16 was utilized to approximate the stress concentration factor, Kt, of the carbon fiber tube member. Table 1 below details the numerical dimensions of the final design used to solve for A, Kt, and Znet. Using linear interpolation, these values were solved to be 0.685, 2.325 and 0.055 respectively.

Table A-16. Table used to approximate the stress concentration factor of the carbon fiber tube with reinforced hole

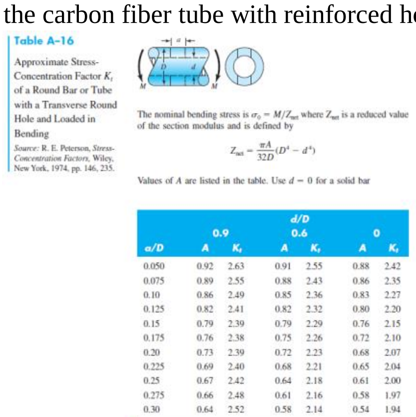


Table A-16

Approximate Stress-Concentration Factor K_t of a Round Bar or Tube with a Transverse Round Hole and Loaded in Bending

Source: R. E. Peterson, *Stress-Concentration Factors*, Wiley, New York, 1974, pp. 146, 235.

The nominal bending stress is $\sigma_0 = M/Z_{net}$ where Z_{net} is a reduced value of the section modulus and is defined by

$$Z_{net} = \frac{\pi A}{32D}(D^4 - d^4)$$

Values of A are listed in the table. Use $d = 0$ for a solid bar

	d/D					
	0.9		0.6		0	
a/D	A	K_t	A	K_t	A	K_t
0.050	0.92	2.63	0.91	2.55	0.88	2.42
0.075	0.89	2.55	0.88	2.43	0.86	2.35
0.10	0.86	2.49	0.85	2.36	0.83	2.27
0.125	0.82	2.41	0.82	2.32	0.80	2.20
0.15	0.79	2.39	0.79	2.29	0.76	2.15
0.175	0.76	2.38	0.75	2.26	0.72	2.10
0.20	0.73	2.39	0.72	2.23	0.68	2.07
0.225	0.69	2.40	0.68	2.21	0.65	2.04
0.25	0.67	2.42	0.64	2.18	0.61	2.00
0.275	0.66	2.48	0.61	2.16	0.58	1.97
0.30	0.64	2.52	0.58	2.14	0.54	1.94

Table 3. This table details the numerical dimensions of the final design for approximating the theoretical stress concentration factor for round tube with transverse round hole loaded in bending

a	0.25 in.
d	0.875 in.
D	1.106 in.
M	1611.11 lb-in.

To obtain the maximum resulting stress due to the hole, the notch sensitivity, q, of the carbon fiber material was considered. This value was discovered to be 0.96. Thus, the fatigue stress-concentration factor, K_f, was reduced from the K_t value previously found using equation 6-32 which was determined to be 1.272.

$$K_f = 1 + q(K_t - t) \qquad (6\text{-}32)$$

With this, the nominal stress was solved to be 37028.708 psi using the moment, M, the reduced value of the section modulus, Z_{net}, and the fatigue stress-concentration factor, K_f.

Lastly, with the assumption of 80 kpsi as the yield strength of carbon fiber and the nominal stress value previously found, the factor of safety of this member loaded in bending for a proposed 200 pound body weight was determined as a value of 2.16. This factor of safety value is deemed acceptable.

The pins themselves were also considered a potential location for failure. A static force analysis was performed on the table to determine how the pins would hold if a force was applied onto the table. Figure 1 shows the calculations used to find the force at the pin. Given a 200 pound person with all of their weight evenly distributed along the seat, it was found that the force at the pin was 179.2 lbs. With a pin of diameter 0.25 inches, that results in a stress of 3664.2 lb/in^2 based on this force. Given the yield strength of stainless steel is approximately 37.5 ksi, the factor of safety on the pins is 10.234, which is very acceptable.

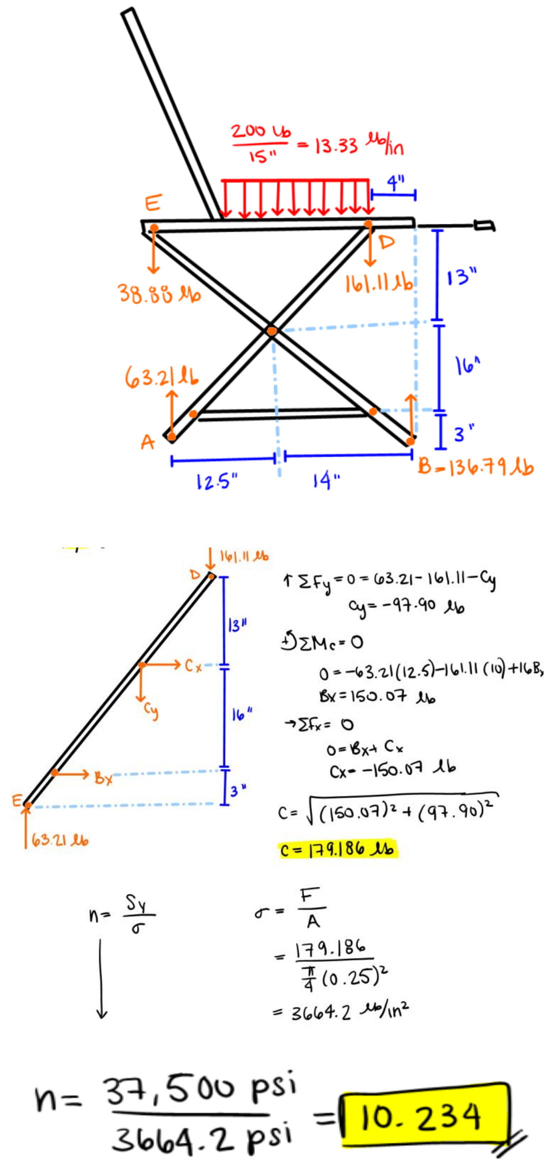


Figure 1: Calculations of the force on the pins

PRODUCT REALIZATION

The final product design consists of three main components: the patient table, the physician's stool, and the stepping stool. The patient table is the majority of the design. Pictured in Figure 2, the table is made out of round, 1-inch carbon fiber tubes, with 6061-T6 Aircraft-grade aluminum joints. Two foam cushions wrapped in heavy-weight black vinyl with polyester backing sewn together to make up the seat cushion and back cushion of the table. The carbon fiber and aluminum joint frame underneath the seat is in a cross form in order to fully support someone that is sitting on the table. There is also a carbon fiber plate screwed onto the frame underneath the seat cushion for added support and comfort. There are carbon plate strips hooking the front and back legs together at the bottom of the legs for added support.

Figure 2. Photograph of the fully assembled table. The table is made out of carbon fiber rods, aluminum joint, and vinyl-covered cushions.

The legs of the table are pinned together at the cross point on each side with zinc-coated, stainless steel pins, both 0.25-inches in diameter. The lower halves of the front and back legs can be removed from the top when the pins are removed to allow the assembly to fold up and stack together for an easily packable and transportable device. The back rest can rotate to accommodate different angles, and there is a locking bar also made out of carbon fiber that locks the back rest to specific angles at 15, 45, and 85 degrees. There are carbon fiber foot rests that rotate out from under the seat and can lock using the aluminum joints. Figure 3 shows a schematic of the carbon fiber frame when the table is completely disassembled. In this form the table is completely flat and can be transported easily to different locations.

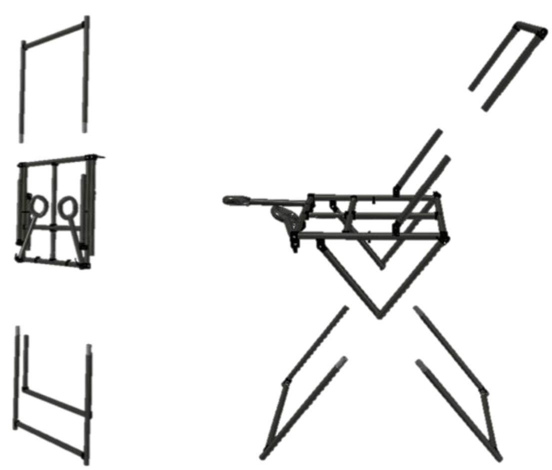


Figure 3. Picture of the disassembly of the frame. The bottoms of the legs remove and the entire table can fold flat for transportation purposes.

Figure 4 shows the doctor's stool. The doctor's stool is made out of the same carbon fiber, aluminum joints, and vinyl cushioning as the table. It consists of a cross brace with one rod sticking straight up to hold the cushion. The vertical rod actually consists of two separate rods that are connected by a 0.25-inch diameter, zinc-plated, stainless steel pin. The seat can be raised and lowered to accommodate varying heights of users.

Figure 4. Picture of the Doctor's stool

The stepping stool, shown in Figure 5 was purchased to use as a stepping stool for patients to use to get onto the table. The average Peruvian woman is 5'3" tall, so the stepping stool makes it easier for them to get up onto the table. The stepping stool is made out of plastic, it can be folded flat, and is rated to hold 300 pounds.

Figure 5. Picture of the stepping stool

This product was designed with the intent of being a specialized device that meets specific design criteria, such as weight, portability, and comfort. It was not designed to be mass produced, and the customization of the carbon fiber and aluminum, which was chosen primarily for its strength-to-weight ratio, resulted in a difficult and time-consuming construction process. The design is intended to be easy to assemble for use, easy to move, and easy to clean, as well as comfortable for participants to use.

Carbon fiber was chosen as the primary construction material because it is lightweight and very strong. A supplier was found that specializes in custom carbon composites, and all of the carbon fiber rods and aluminum joints were purchased from them. As they sell a wide variety of materials, and tolerancing can be specified on custom orders, the manufacturing tolerance was not considered to be an issue when designing the product. Material selection was considered throughout the design process. Using carbon was considered in the early design stages, and the many improvements and changes that were made throughout the design process were done so with the intent of using carbon fiber in the final product.

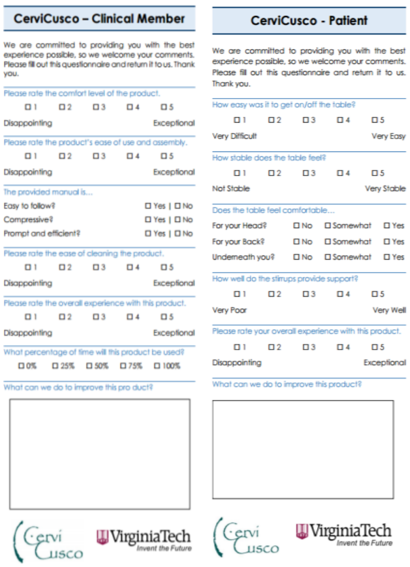
The product is intended for use in the main CerviCusco medical center in Cusco, Peru, as well as in the villages and remote locations that the CerviCusco staff conducts their services. The table was designed to be used in an identical manner to a normal gynecological examination table. It was intended to be used in pap tests, screenings, and any procedures or surgeries that a normal table might be used for. It does have some design restrictions, such as it is not intended to be used with patients over 200 pounds, but otherwise it can be used like any other exam table.

The product was designed and built to fully accommodate the customer needs. The main customer needs that our client identified were that the product should be lightweight, simple design, comfortable, and easily cleanable. All of these requirements were met based on the design and materials that were chosen. The product is of sufficient weight, it has a simply assembly procedure, it is comfortable, and it can be completely cleaned using disinfecting wipes, or a solution of diluted bleach or acetone. The adherence to the customer needs was tested using a validation plan that is described in detail below.

TEST AND EVALUATION RESULTS

We developed a testing plan for our project based off of the target specifications that have been discussed earlier on. These tests were designed to prove that the table performed properly and as per the requirements that were set in the beginning of the year. These tests also help create rules and guidelines for use when we hand of the project to the client to ensure safety and dependability. There were a total of 5 tests that have been created which consist of an ergonomics, sterility, articulating motion, minimal parts number, and weight test. These tests along with their details and results will be further described below.

The first test plan that was designed is that of the ergonomics test. This is a very important test that needs to be done because patients will be utilizing this table during strenuous procedures and examinations so it is necessary for comfort and durability. This test is yet to be done as it will be done from May 16th to the 21st in Peru when the team is to visit CerviCusco. We will be testing up to 20 medical professionals and up to 50 women patients. The exclusions for this test is any personnel over 200lbs and pregnant women. This test will be done in conjunction with an official IRB approval. This test plan would have test subjects sit in the table and rate its ergonomics through the use of a verbal survey shown in Figure 6. They will be rating the comfort, ease of use, stability, and overall experience of the table itself. The only instrumentation that would be required in this plan would be the test subjects themselves.



CerviCusco – Clinical Member

We are committed to providing you with the best experience possible, so we welcome your comments. Please fill out this questionnaire and return it to us. Thank you.

Please rate the comfort level of the product.
☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5
Disappointing — Exceptional

Please rate the product's ease of use and assembly.
☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5
Disappointing — Exceptional

The provided manual is...
Easy to follow? ☐ Yes | ☐ No
Compressive? ☐ Yes | ☐ No
Prompt and efficient? ☐ Yes | ☐ No

Please rate the ease of cleaning the product.
☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5
Disappointing — Exceptional

Please rate the overall experience with this product.
☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5
Disappointing — Exceptional

What percentage of time will this product be used?
☐ 0% ☐ 25% ☐ 50% ☐ 75% ☐ 100%

What can we do to improve this pro duct?

CerviCusco — VirginiaTech Invent the Future

CerviCusco - Patient

We are committed to providing you with the best experience possible, so we welcome your comments. Please fill out this questionnaire and return it to us. Thank you.

How easy was it to get on/off the table?
☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5
Very Difficult — Very Easy

How stable does the table feel?
☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5
Not Stable — Very Stable

Does the table feel comfortable...
For your Head? ☐ No ☐ Somewhat ☐ Yes
For your Back? ☐ No ☐ Somewhat ☐ Yes
Underneath you? ☐ No ☐ Somewhat ☐ Yes

How well do the stirrups provide support?
☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5
Very Poor — Very Well

Please rate your overall experience with this product.
☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5
Disappointing — Exceptional

What can we do to improve this product?

CerviCusco — VirginiaTech Invent the Future

Figure 6. Surveys to be given in Peru to Test Subjects

The second test that was designed was the sterility test. This test is very important for all medical procedures and is necessary for the safety of the patient. To perform this test water was poured onto the table and left to sit for 5 minutes. Then it was wiped away and the table was inspected for how much water was absorbed or repelled. The test would pass if the table is completely dry and no water is absorbed. The results of this test lead to a success and the vinyl of the cushion repelled all of the water from absorbing into the cushion. The water beaded up as pictured in Figure 7 and failed to seep through the material. Furthermore, the vinyl was cleaned using alcohol wipes, diluted bleach, and an acetone solution with a 1:4 ratio with water.

Figure 7. Sterility Test from left to right as the table is wiped down.

The articulating motion test is important for proper patient position during the examination as specified by the doctor. The requirement was that the table can rotate between various degrees of articulation between 90 and 0 degrees. This test was successful as shown in Figure 8, in which the table can be angled at 15, 45, and 85 degrees.

Figure 8. Articulation of Table from left to right 15, 45, & 85º

Next the minimal parts number test is important for the ease of use portion of the project. As there is a possibility to loose small parts if there are more than a few it, is important that the design was simple. Our metric for this was that the number of parts needed to be less than 15. We were successful in that including the back pack and pins the total number of separate parts is 11 as listed:

Parts List:

- Main Table Frame
- Front Leg U-assy
- Back Leg U-assy
- Back Rest U-assy
- Seat Cushion
- Leg Pins (x2)
- Doctor Stool
- Doctor Stool Pin
- Stepping Stool
- Backpack

Finally, the last test that was required to be performed as per our specifications is that of the weight test. This is important as the design of only the table needed to be portable and backpack-able and thus weigh under this requirement. To perform this test we calibrated and used the scale provided to us at McCommas Hall at Virginia Tech shown in Figure 9. We were successful in this test as the table itself weighed out to be exactly 20lbs. Furthermore, the additional doctor stool and stepping stool weighed 2.5lbs each. The backpack used to carry everything added on another 4.5lbs totaling a weight of 29.5lbs for the whole set of equipment.

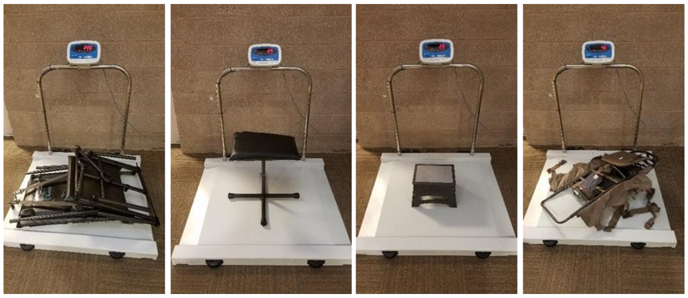


Figure 9. Weight Test of all 5 main design sections.

Overall our design has successfully performed all of its functions properly and as we required it to. Following, its verification it was important to determine where our design lays on the Technology Readiness Scale (TRL). This scale is rated from 1-9 with 9 being a design in its final form, and the technology being proven through successful operations. With our current analysis and implementation of this table in Peru we can give our design a TRL score or 9 as it is in its final form and fully functional to be utilized. With that being said for further research and drive towards production there are a few recommendations that could improve the design. The first of those is to angle the stirrups upwards slightly, to improve support and comfort for the patient. Next, this table to its core can actually be used for various other medical procedures with slight adjustments to the design. Therefore, by making the base structure of the table common and identifying the stirrups as add-ons the total scope of the table can be altered. For example, the stirrups can be removed and a slide out leg support can be added to allow this table to operate as a fully functioning dental screening table and so on. Finally, the last and biggest consideration is the material selection of the table. Currently, our specification was for the table to weigh less than 20lbs but if the limit was increased to about 40lbs the cost of the overall table can be reduced significantly. Thus, this allows the table to be much more affordable and still function as a portable, durable, and lightweight cervical cancer screening table. In the end, for what our design criteria and specifications were our project was successful.

TABLE 1: TRL LEVELS

Technology Readiness Level	Description
TRL 1.	Scientific research begins translation to applied R&D - Lowest level of technology readiness. Scientific research begins to be translated into applied research and development. Examples might include paper studies of a technology's basic properties.
TRL 2.	Invention begins - Once basic principles are observed, practical applications can be invented. Applications are speculative and there may be no proof or detailed analysis to support the assumptions. Examples are limited to analytic studies.
TRL 3.	Active R&D is initiated - Active research and development is initiated. This includes analytical studies and laboratory studies to physically validate analytical predictions of separate elements of the technology. Examples include components that are not yet integrated or representative.
TRL 4.	Basic technological components are integrated - Basic technological components are integrated to establish that the pieces will work together.
TRL 5.	Fidelity of breadboard technology improves significantly - The basic technological components are integrated with reasonably realistic supporting elements so it can be tested in a simulated environment. Examples include "high fidelity" laboratory integration of components.
TRL 6.	Model/prototype is tested in relevant environment - Representative model or prototype system, which is well beyond that of TRL 5, is tested in a relevant environment. Represents a major step up in a technology's demonstrated readiness. Examples include testing a prototype in a high-fidelity laboratory environment or in simulated operational environment.
TRL 7.	Prototype near or at planned operational system - Represents a major step up from TRL 6, requiring demonstration of an actual system prototype in an operational environment.
TRL 8.	Technology is proven to work - Actual technology completed and qualified through test and demonstration.
TRL 9.	Actual application of technology is in its final form - Technology proven through successful operations.

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