Outreach Activities from First-Year Engineering Projects

Abstract

In April 2012, the Mind Trekkers group from Michigan Technological University attended the 2nd USA Science & Engineering Festival in Washington D.C. Mind Trekkers is an outreach organization that focuses on making STEM accessible to all age groups through action-packed hands-on learning. This learning often takes place in short demonstrations or activities. One of these activities was modified from a first-year engineering project on wind energy as part of the IDEAS Project (DUE-0836861).

For the semester project, student teams developed a bench-scale wind turbine. They measured the turbine performance by measuring the RPMs, torque, and wind velocity. They used Excel to analyze their team and class data. The project was updated and modified for Mind Trekkers. In this adaptation, six turbine blades consisting of three different geometries (flag, rectangular, and leaf) were constructed. Participants selected the number and type of blades to insert into a KidWind hub. The KidWind hub was attached to a generator and pre-fabricated turbine stand. Students were able to adjust the blades they chose and blade pitch in order to maximize the voltage produced.

This paper focuses on this adaptation of a first-year engineering project to K-12 outreach. It outlines the adaptation process from a semester-long project to a 3-5 minute learning experience. As the need for STEM outreach continues and grows, the need for new and unique activities also increases. The adaptation of existing work is one way to increase the number of activities available. Also, the adaptation of university-level projects to these outreach programs is significant because it begins to show participants what STEM students do and accomplish within the university environment.

Introduction

The first-year engineering program at Michigan Technological University (Michigan Tech) is comprised of two (or three) semester courses depending on math readiness. Each course is designed to promote active, hands-on learning. Within each course, students complete in-class activities and a semester design project as a part of an engineering team typically composed of four students. A wind energy project was developed as part of the NSF funded IDEAS project (DUE-0836861). This project requires students to design, build, test, and analyze a lab-scale horizontal axis wind turbine. The goals of this project were to create project modules that could be easily adaptable to various curriculums and applications, including K-12 programs.1

In 2010 – 2012, three project modules were integrated into the first-year curriculum at Michigan Tech: aquaculture, biomechanics, and wind energy. For the aquaculture module, students built, tested, and analyzed their own aerator or used 3D modeling to develop a new impeller for an existing pump to use in water circulation. Students working on the biomechanics module created a prosthetic leg device and analyzed the motion and forces generated during the kicking movement. Students completing the wind energy module created a lab-scale wind turbine and/or created new blades for an existing base using 3D modeling and design.2 These projects were
assigned by the instructor and used in various sections of the first-year engineering courses. For example, in the fall semester of 2010, all three modules were used in four sections. One section of students completed the biomechanics module (n=41), one completed the wind energy module (n=43), and two completed the aquaculture module (n=73).

In general, these projects have been received favorably with the first-year students as shown in Table 1 below, which summarizes responses from a survey conducted at the end of the semester. Note this data is a tabulated total of all responses in all sections between fall 2010 and spring 2011 where this survey was used. The number of students provided in the previous paragraph was only for fall 2010. The majority of students found the projects to be applicable to engineering. They were easily able to apply their knowledge of engineering design and liked the projects. The wind energy module has been utilized the most as it has been found to be the most adaptable to various classes in the first-year program and our summer youth programs. The aquaculture module has been used for design projects in three of the last five semesters. The biomechanics module has been used for summer youth and in the fall semester of 2010. It was determined then that the students needed more math background to perform a meaningful analysis of the leg motion. For summer youth, however, it was found to be one of the most popular projects selected by students and viewed at the student showcase.¹

Table 1. Student responses to end of term project survey ¹, ³

<table>
<thead>
<tr>
<th>Likert Scale Question</th>
<th>Wind Energy (n=151)</th>
<th>Aquaculture (n=97)</th>
<th>Biomechanics (n=50)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I can clearly see the engineering application of our design project.</td>
<td>80.1%</td>
<td>82.5%</td>
<td>73.5%</td>
</tr>
<tr>
<td>The engineering aspects of the design project were challenging.</td>
<td>53.6%</td>
<td>67.0%</td>
<td>73.5%</td>
</tr>
<tr>
<td>The design project used skills we learned in our engineering class.</td>
<td>78.1%</td>
<td>92.8%</td>
<td>65.5%</td>
</tr>
<tr>
<td>I understood the limitations of the design better after doing the testing in the learning center.</td>
<td>81.4%</td>
<td>85.6%</td>
<td>76.0%</td>
</tr>
<tr>
<td>I was able to easily use the testing information to analyze the project.</td>
<td>70.2%</td>
<td>79.4%</td>
<td>58.5%</td>
</tr>
<tr>
<td>I liked designing our own impeller / wind turbine blades / artificial leg.</td>
<td>80.1%</td>
<td>93.8%</td>
<td>77.5%</td>
</tr>
<tr>
<td>I would like to see more interactive design projects in the first-year engineering courses that combine physical testing, modeling, and design.</td>
<td>81.4%</td>
<td>86.6%</td>
<td>96.0%</td>
</tr>
</tbody>
</table>

The original plan was, once the projects were developed, to post them on Engineering Pathway (part of the National Science Digital Library) ⁴ and MERLOT ⁵ Both of these online educational
portals allow instructors to post instructional materials that other instructors can then adapt to use in their classrooms. These seemed to be ideal repositories for our work on the IDEAS project. However, while these projects have been popular within the first-year engineering program at Michigan Tech, we wanted to verify that they could be adapted and interesting to a wider audience. To aid in this, we enlisted the help of Mind Trekkers.

The Mind Trekkers organization is a student organization at Michigan Tech that travels the country sharing over 100 science, technology, engineering, and math (STEM) demonstrations with students and their families. All of the demonstrations are 3-5 minutes long, hands on, and exciting. The volunteers, Michigan Tech students, are trained so that they can explain the science behind each demo and answer any questions that might be asked. Mind Trekkers events are always free and focus on one goal: get kids excited about learning. Students involved in Mind Trekkers have a lot of fun traveling and teaching and have commented that “the most exciting part [of Mind Trekkers] is knowing that you inspired a student to learn”.

One Mind Trekkers student worker commented:

“At a Mind Trekkers event, tables with demos are set up for students to come and explore. When they walk up, we give our description and challenge them to participate and learn. When they succeed on their first try, the smiles are unforgettable. When they fail, participants will keep trying until they succeed; rarely do students want an answer given to them. They want to be challenged, they want to problem solve, and they want to succeed. Mind Trekkers gives them the opportunity to do so and in a fun and rewarding way. We, as Mind Trekkers, are teaching students valuable skills that they can use later on and also, that learning can be fun!”

Mind Trekkers’ demonstrations have a formal lesson plan that has been prepared with the events in mind. The lesson plan format includes a list of materials, set up instructions, safety tips, a procedure for how to perform the demonstration, sample questions to ask students, and national K-12 standards. All of the demonstrations have been linked to National Standards so that teachers can use them in the classroom. The lesson plans are posted on the group’s open-access website and teachers are encouraged to use them to make the classroom learning experience more exciting. These lesson plans are posted so educators can reproduced the impact of Mind Trekkers activities in their own classroom, replicating the informal education environment created by Mind Trekkers.7

Research shows that when the fixed intelligence message is replaced with a more malleable view and more informal learning opportunities are offered, the achievement gap virtually disappears. Positive, high-energy communication of this message is key in helping participants realize that STEM learning is a life-long discovery process of fun and engaging “opportunities”. Once students see there is no set “end” or “grade” to define STEM achievement, tenacity to figure things out increases. This is especially true for female, low income students, and underrepresented racial minority students. Informal learning opportunities are a place to emphasize discovery and creativity in a risk-free environment. Our experience shows how all students, when given a personal and social context for learning, have fun in figuring out possible solutions to real-world applications, through tacit and explicit understanding of STEM concepts.
Adapting the first-year engineering semester projects to a 3-5 minute active demonstration was a complicated task. Our first step was to create a lesson plan using the Mind Trekkers ten-step outline as described below:

1. Time required for demonstration
2. Materials needed
3. Set up instructions
4. Safety
5. Lesson’s big idea
6. Instructional Procedure
7. Assessment
8. Conclusion
9. Clean Up
10. Reference

The plan required the instructor to not only list the materials used and desired set up, but also to provide the demonstrator with sample questions for assessment and the key STEM principles the demonstration covered. For example, the wind energy project focused primarily on how a wind turbine’s blade shape, size, number, and angle all affect the turbine’s performance. (The lesson plan for our wind energy project can be found in Appendix A.) In contrast to our first-year project where students had to build their wind turbines, our adaptation allowed K-12 students to test three different pre-manufactured blade designs. Participants could choose which blades to use, what configuration they desired, and test to see the voltage their designs produced.

For the biomechanics project, instead of constructing a prosthetic leg, participants tested a pre-manufactured leg to see how the joint worked and how effective the kicking motion was. Our Mind Trekkers lesson plan focused on the knee and how it worked. Students measured the range of motion of the leg and compared it with their own using a goniometer. An example STEM concept that students could learn from this activity was that more force can be generated with a larger range of motion. In this case, students could move the leg back at increasing angles and kick a ball with more force into a tower of cups. (The lesson plan for our biomechanics project can be found in Appendix B).

We also developed supplemental posters to provide students with more information as shown in Figures 1 and 2. The wind energy poster detailed basic information on how the blades work, how much power can be generated, and where the wind potential can be found in the United States. The biomechanics poster discussed how to calculate the overall range of motion of the leg and how to measure it using a goniometer.
USA Science & Engineering Festival

In April 2012, Mind Trekkers took a team of 16 students to participate in the 3-day USA Science and Engineering Festival. Hosted at the Walter E. Washington Convention Center, there were over 470,000 square feet of STEM related activities and presentations and over 250,000 students and families who participated in the event over the three days. All activities in the Mind Trekkers area were fully engaged throughout the entire event, at times experiencing lines of up to 15 individuals deep waiting to conduct the activities.

The adapted wind energy and biomechanics modules were tested in this fast pace interactive environment. Figure 3 below shows students assembling and testing their blade configurations. Students could choose from three pre-manufactured blade designs to create their blade configurations. These blades were made from plastic 2-liter bottles due to the natural curvature of the material and attached to dowel rods that fit inside a standard KidWind hub. Each of the blades performed differently by themselves. The most effective design appeared to be the flag shape (red) followed by the leaves (green), and then the rectangular blades (blue). However, students were free to mix and match blades and most students chose to test a combination of blade types.

This activity appeared to be most popular with the younger audience (K-7). They enjoyed picking and choosing which blades to use and putting them in the hub. Testing their creations appeared to be anticlimactic. We had a multimeter set up so that they could measure the voltage generated by the designs. However, this number without...
context really did not impress them. They enjoyed getting a “better” number than their friends, brothers, or sisters, but did not really understand what that meant.

We were able, however, to demonstrate how blade pitch affected their designs. Quite often, the demonstrator was able to make a slight change to the alignment of the blades and students were able to see how this simple change dramatically affected their turbine’s performance. This correlation between blade alignment and efficiency was one of the “take away” ideas that students left with.

To create the prosthetic limb used in the biomechanics module, we used PVC piping for the “bones”, a chair wheel and brackets to simulate the knee joint, and rubber tubing was used to simulate the ligaments holding the bones together. The tubing provided tension as the leg was pulled back. When the leg was released, it would swing forward, kicking a ball into a tower of cups. As shown in Figure 4, the prosthetic limb was clamped underneath a table and therefore was not easily visible to the waiting crowd. This project did not get the attention of the wind energy project and appeared to be most popular with the youngest audience (pre-K – 2nd grades). While, the main goal of this project was to introduce students into the basic physiology of the leg and how the joint / leg works, the younger children just enjoyed knocking down the tower of cups. Some major modifications are needed to make this project a) more visible, and b) more active than just pulling back the leg.

![Figure 4. Students testing prosthetic leg](image)

**Assessment**

While we have anecdotal evidence of success or ideas for improvement, the challenge of informal STEM outreach events such as the 2nd USA Science & Engineering Festival is that the high traffic, open-to-the-public nature of the events is not conducive to gathering data to measure program effectiveness. Mind Trekkers has created several two-day science and engineering festivals modeled off of the USA Science and Engineering Festival’s operating structure. The first day of the event has two – 2 ½ hour sessions that schools register for. In this registration process, participant teachers contact information is collected which allows Mind Trekkers to work with teachers to administer pre- and post-student surveys.

In April of 2012, Mind Trekkers conducted the Sheboygan Science and Engineering Festival sponsored by Kohler Co. in which these pre- and post-surveys were administered to the 1,600+ participants. The results in Table 2 show that in each of the STEM fields there was an increase in
participant interest. The highest gains were in science (29% increase in extremely interested, 10% increase in area from students with no initial interest) and engineering (14% gains in extremely interested, 16% increase in area from students with no initial interest). Slight gains occurred in technology (6% gains in extremely interested, 5% increase in area from students with no initial interest) and math (13% gains in extremely interested, 2% increase in area from students with no initial interest).

Table 2. Sheboygan Science and Engineering Festival Survey Results

<table>
<thead>
<tr>
<th>Interest Level In:</th>
<th>Pre</th>
<th>Post</th>
</tr>
</thead>
<tbody>
<tr>
<td>Science</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Extremely</td>
<td>38%</td>
<td>67%</td>
</tr>
<tr>
<td>• Moderately</td>
<td>52%</td>
<td>33%</td>
</tr>
<tr>
<td>• None</td>
<td>10%</td>
<td>0%</td>
</tr>
<tr>
<td>Technology</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Extremely</td>
<td>45%</td>
<td>51%</td>
</tr>
<tr>
<td>• Moderately</td>
<td>44%</td>
<td>43%</td>
</tr>
<tr>
<td>• None</td>
<td>11%</td>
<td>6%</td>
</tr>
<tr>
<td>Engineering</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Extremely</td>
<td>35%</td>
<td>49%</td>
</tr>
<tr>
<td>• Moderately</td>
<td>41%</td>
<td>43%</td>
</tr>
<tr>
<td>• None</td>
<td>24%</td>
<td>8%</td>
</tr>
<tr>
<td>Math</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Extremely</td>
<td>22%</td>
<td>35%</td>
</tr>
<tr>
<td>• Moderately</td>
<td>56%</td>
<td>45%</td>
</tr>
<tr>
<td>• None</td>
<td>22%</td>
<td>20%</td>
</tr>
</tbody>
</table>

From informal surveys of teachers 6 months after attending our events, a large majority of teachers stated that students were still referring to their festival experiences during the course of classroom discussions. Further follow-up with teachers is an opportunity to longitudinally review the impact of the events on student’s performance.

Adaptations of IDEAS Projects – Take 2

Although the biomechanics and wind energy modules had successful pilot runs, both projects require improvements to create a more interactive and interesting experience for Mind Trekkers participants.

The Mind Trekkers staff had the following suggestions for the wind energy project:

1. Let the participants construct blades quickly from different materials
2. Allow the participants to test their designs using a meter that shows the energy produced. The power display should be large and elevated so others can see results. This will challenge participants to create a better design and give them a ‘number’ to beat.
3. Use a more powerful fan with variable speeds (not just a 3-speed fan).
4. Show a video on a large screen TV on the side of wind turbines in action, showing how they operate in a storm. The students would be interested to see the videos showing a turbine spinning too fast and breaking apart, illustrating design challenges.

5. Have the cross section of a real wind turbine fuselage on display adjacent to the project area.

For the wind energy project, items 1-3 above (permitting participants to create their own blades, provide an adjustable fan speed, and have a stronger fan) would be simple to implement. Some suggestions for blade materials are: paper plates, transparency material, cardstock paper, dowel rods, and tape. The dowels would be reusable. We would continue to provide the wind turbine base, KidWind hubs and generators. Students would be able to design their own blades, cut them out, tape them to the dowel rods and test them in the wind turbine. We have acquired a visual voltmeter (shown in Figure 5) that can be hooked up to the KidWind generator. This voltmeter provides a visual representation of voltage (by number of LEDs lit) instead of a numerical result, but it is small. We could set up two stations, one with a direct-drive system, where the blades directly turn the generator and one set-up where the blades turn gears that turn the generator to compare which produces the most power.

The Mind Trekkers staff had the following suggestions for the biomechanics project:

1. Changing the location of the leg to a better demo area. Several Mind Trekkers demos are on the floor and are sometimes overlooked when they are placed next to tabletop demonstrations.

2. Adding an additional measurement for students to complete besides range of motion to change the focus from knocking down the tower into how the leg and knee function.

3. Use joints with different configurations in kicking a ball: partial circular motion, oblong motion, 360° circular motion, etc. Have students make their own hypothesis on which one works best and why by studying the motion of the joint and the resulting distance the ball travels after being kicked. There could be some constructed with variations between each of these, offering clear variables for the students to compare/contrast and create theories to why this affects their performance.

The biomechanics project had disappointing results. It was rated highly by the students involved in our summer-youth program, but it did not translate well to a Mind Trekkers demonstration. From the above list, item 1 would be the easiest to implement, however, this does not really change the nature or address the technical issues with the demo. Manufacturing different joints for the existing leg would require significant modifications to the original leg prototype and would be difficult to implement in a timely manner. Additional thought must be put into this project before it would be ready to use at other Mind Trekkers’ events. When the biomechanics project is used in the summer youth program again, assessment data will be collected to determine which components of the project most excited and/or interested the students. With this
information, the Mind Trekkers biomechanics demonstration would be modified to highlight these aspects of the project.

The Wind Energy (Blow Me Away!) project is an activity that is readily adaptable to any STEM related informational meeting, workshop or engineering/science night. The lesson plan, along with other Mind Trekkers activities, is listed on their web site (http://mindtrekkers.mtu.edu/) and at the end of this paper. The Biomechanics (Finding Knee-Mo) lesson plan is also shown below. It could be used to excite younger students in STEM fields. It would be a great demonstration activity for K-2 students. Not only would this activity interest students in engineering, but in learning how the leg works in an easy to see model.

Future Plans
Michigan Tech’s Center for Pre-College Outreach conducts a wide variety of outreach programming involving K-12 students. One of these programs is the Gaining Early Awareness and Readiness for Undergraduate Programs (GEAR UP). Sponsored through the U.S. Department of Education, GEAR UP is focused on increasing the number of low-income students who are prepared to enter and succeed in postsecondary education. Michigan Tech’s cohort consists of 400+ areas students who are in 8th grade. Using the Mind Trekkers program, we will test out our new activity design and additional supporting components on this cohort to gain feedback regarding factors such as:

1) Enthusiasm with engagement
2) Extent of duration of the engagement (did they redesign and test again)
3) Depth of exploration of the science behind it (how many questions did they ask to gain a deeper understanding)
4) To what degree did they engage with each supporting component (self-reported)

Once modifications are completed to the wind energy activity it will be taken on the road with Mind Trekkers to science and engineering events. Additional results obtained from the use of this project at the Mind Trekkers events will be included in our ASEE presentation.

Some of the 2013 Mind Trekkers events include:

- College of Lake County Science and Engineering Festival, April 12, 2013 (2,000+ participants)
- Northeastern Wisconsin Technical College Science and Engineering Festival, April 18, 2013 (2,000+ participants)
- Fox Valley Science and Engineering Festival, April 19 & 20, 2013 (5,000+ participants)
- Destination Imagination 2013 Global Finals, May 22-25, 2013 (16,000+ participants)
- 2013 National Boy Scout Jamboree, July 15 – 24, 2013 (42,000+ participants)

Conclusions
Michigan Technological University has a reputation among the corporate community for producing scholars that possess not only a strong intellect, but the ability to practically apply and communicate that knowledge. The Department of Engineering Fundamentals is instrumental in providing hands-on active learning activities ensure development of these skills. The goal of
Mind Trekkers and Michigan Tech is to attract K-12 students to STEM and retain them within STEM as they pursue university degrees. Over the past two years, first-year engineering design modules have been adapted to Mind Trekkers with varying success. The wind energy project, with minor alterations, is a great addition to the Mind Trekkers program. The lesson plans provided by Mind Trekkers allow other outreach programs and instructors at various levels to implement these demonstrations and activities in their own programs. The informal learning opportunities provided by these types of activities promote STEM learning as a discovery process of fun and engaging “opportunities”. Female, low income and underrepresented students in particular benefit from a risk-free discovery based learning environment.

Mind Trekkers works with undergraduate/graduate students to create and re-engineer activities for the purpose of successfully communicating STEM concepts to K-12 students. These skills closely align with what industry values about graduates from Michigan Tech. The added benefit of utilizing these first-year engineering projects to engage Mind Trekkers event participants in exciting STEM activities is that it allows students and their parents to ‘get a taste’ of what their college experience will be like. Mind Trekkers team members not only become ‘near peers’ mentors, they become role models for each K-12 student. These newfound mentors and role models prove that if they are inspired and successfully engaged in their collegiate education, so can they.

References

Appendix A: Mind Trekkers Lesson Plan – Wind Energy

Blow Me Away

Amount of time Demo takes: 03:00-05:00 minutes

Materials (be as thorough as possible):

1. Wind Turbine Base
2. Wind Turbine Motor and Rotor
3. 1-3 Sets of Pre-Made Turbine Blades (6 each)
4. Multimeter or Voltmeter (0 – 2V)
5. Wind Energy Poster
6. Easel for poster to be placed on
7. 3 Speed Box Fan
8. Extension Cord

Set up instructions:

1. Assemble base.
2. Set-up poster with voltmeter attached.
3. Set up wind turbine stand.
4. Connect positive (red) and negative (black) connections between wind turbine motor and voltmeter.
5. Place sets of turbine blades out for participant selection.
6. Place poster on easel and attach voltmeter to it.

SAFETY! What precautions do you or participants need to take or things to be aware of? Safety equipment used, electrocution, burns, chemicals etc.

Since the motor is generating electrical power and a voltmeter is being used, the table and equipment should be kept dry and away from water.

Lesson’s big idea (What is the demo/lessons objective or big idea briefly? explain in 1-3 sentences in bullet points)

- Wind turbine power generation is a function of: the number of turbine blades and their angle.
- Wind turbine power generation is affected by the shape of the turbine blades

Instructional Procedure (VERY detailed how-to guide and background information needed to teach and fully understand this demo and concept. This could be handed to anyone and they could teach it based on what you write, can include a script, or tips/tricks, jokes that work with demo etc.)
1. Pick a blade design (Participants should select the number and type of blades that they want to test (one blade type))
2. Choose number of blades
3. Insert blades into the turbine rotor. Blades should be placed in the turbine rotor carefully. There is a wing nut that needs to be loosened such that the blades can be inserted into the rotor. Wing nut needs to be tightened to secure blades
4. Have MindTrekker rep attach the turbine rotor to the base
5. Turn on the fan on low, medium then high speed
6. What voltage is displayed on the voltmeter?
7. What happens if your blades are not spaced evenly on the turbine rotor?

Assessment (How do you know your audience understood?)
Sample questions you can ask:

1. What happens if you angle the blades?
2. What happens if you change the number of blades?
3. What happens if your blades are not spaced evenly on the turbine rotor?

Conclusion (Review concepts covered briefly if summary needed)

Clean Up
Clean up between demonstrations if needed. When completely finished gather all materials listed for this demonstration and make sure everything is accounted for. If something was used up, broken or damaged. Let someone know so it can get replaced or fixed.

References (Include any websites, books etc that 1, back up your explanation of the demo, and 2, someone can go to find more information.):

http://www1.eere.energy.gov/windandhydro/pdfs/
http://windeis.anl.gov/guide/basics/index.cfm
http://www.windpoweringamerica.gov/
http://www.awea.org/
Wind Power for Dummies, Ian Woofenden, 2009
http://en.wikipedia.org/wiki/Wind_power
http://en.wikipedia.org/wiki/Wind_turbine_design
http://learn.kidwind.org/sites/default/files/advancedblades.pdf

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Appendix B: Mind Trekkers Lesson Plan – Biomechanics

Finding Knee-mo

Amount of time Demo takes: 03:00-05:00 minutes
Materials (be as thorough as possible):

1. Artificial Leg Setup
2. Large Clamps
3. Stand for Ball
4. 1-3 Foam Balls
5. 6 – plastic containers to use as a target.
6. Net for Ball (we are using poster stands and a sheet of fabric stretched between them and clamped on with binder clips)
7. Poster
8. Easel for poster to be placed on
9. Regular size table
10. Goniometers
11. Extra bungee cord and connectors

Set up instructions:
1. Set-up net, tower of plastic containers, and ball stand.
2. Set up poster stand and poster
3. Clamp artificial leg to table and connect to stand to add tension to leg.
4. Adjust pant leg to cover bungee cord.
5. Set up goniometer next to leg.
6. Set ball on ball stand

SAFETY! What precautions do you or participants need to take or things to be aware of? Safety equipment used, electrocution, burns, chemicals etc.

Do not stand in front of leg when kicking. People should push leg back from the side. Net should be placed so it will stop ball from rolling away.

Lesson’s big idea (What is the demo/lessons objective or big idea briefly? explain in 1-3 sentences in bullet points)

- More force can be generated with a larger range of motion.
- Knees are used in a lot of different sporting activities.
- The human leg: Consists of femur, tibia, and patella bones. Allows for extension, flexing, and some rotation. Surrounded by muscles, ligaments, tendons, and cartilage

Instructional Procedure (VERY detailed how-to guide and background information needed to teach and fully understand this demo and concept. This could be handed to anyone and they could teach it based on what you write, can include a script, or tips/tricks, jokes that work with demo etc.)
1. Set up ball on stand.
2. Move leg backward to 80° angle, and release to kick ball. Ball should be kicked into pyramid of plastic containers.
3. Restack containers and replace ball.
4. Repeat kicking with decreasing angles.
5. Use the goniometer to measure the students own leg motion.
   - Measure your leg angle fully extended
   - Measure your leg angle fully bent

Assessment (How do you know your audience understood?)
Sample questions you can ask:

1. What happens when you bend the leg farther?
2. What is your range of motion?
3. What would happen if the knee was injured? (torn ligament, tendons…)

Conclusion (Review concepts covered briefly if summary needed)

Clean Up
Clean up between demonstrations if needed. When completely finished gather all materials listed for this demonstration and make sure everything is accounted for. If something was used up, broken or damaged. Let someone know so it can get replaced or fixed.

References (Include any websites, books etc that 1, back up your explanation of the demo, and 2, someone can go to find more information.):

“Muscles involved in knee motion”


Created by: Amber Kemppainen (amber@mtu.edu) and Gretchen Hein (glhein@mtu.edu), Department of Engineering Fundamentals, Michigan Technological University

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