2006-805: PARTNERING WITH A NEIGHBORHOOD ASSOCIATION TO BRING TECHNOLOGY TO AT-RISK URBAN STUDENTS

Margaret Ratcliff, Purdue University-Columbus/SE Indiana
Margaret Ratcliff is an Assistant Professor in Mechanical Engineering Technology at Purdue University College of Technology in Columbus, Indiana and has been there since January 2005. Before joining Purdue University at Columbus, she spent 11 years in industry working mostly as a Product Design Engineer, Senior Project Engineer, and Structural Analyst. She earned a M.S. degree in Mechanical Engineering from Texas A&M University and a B.S. degree in Mechanical Engineering from Tulane University.

Joseph Fuehne, Purdue University-Columbus/SE Indiana
Joseph P. Fuehne is an Assistant Professor in Mechanical Engineering Technology at Purdue University College of Technology in Columbus, Indiana. He earned Ph.D. and M.S. degrees in Mechanical Engineering from Texas A&M University and a B.S. degree in Aeronautical/Astronautical Engineering from the University of Illinois. Dr. Fuehne is a licensed Professional Engineer in both Texas and Indiana. 
PARTNERING WITH A NEIGHBORHOOD ASSOCIATION TO BRING TECHNOLOGY TO AT-RISK URBAN

An element of Purdue University’s strategic plan involves encouraging technology education through K-12 outreach programs. Consistent with this mission, the authors applied for and received a grant from the Meridian Kessler Neighborhood Association of Indianapolis to deliver math and science-based workshops using LEGO™ models. The purpose of the Meridian Kessler Neighborhood Association is, “to bring about a closer relationship between all people, welcome new residents and businesses, monitor zoning and guard against illegal conversion of single-family housing, maintain quality schools in the area, and provide adequate municipal services for all residents.” Clearly, their mission revolves around improving the quality of life in their neighborhood and this grant supports that mission. This neighborhood is located approximately 4 miles north of downtown Indianapolis.

The authors worked with personnel from St. Joan of Arc elementary school, located within the neighborhood boundaries, to tailor the workshops for the appropriate grades for maximum effect. There were 46 student participants from the 4th, 5th, and 6th grades. The LEGO™ set used for the workshops was the pulleys mini-set. Students were asked to follow directions that included only pictures to assemble several machines using the pulleys. These illustrated directions were important since there were a few students who were challenged to communicate using English.

The students were introduced to some basic engineering concepts in a way they could relate to easily. The workshop encouraged the students to practice their problem solving skills, spatial coordination skills, and critical thinking skills. Several problems without directions or solutions were presented at the end of the workshop. Assessment of learning occurred using a test administered before and after the workshop. Since the students were from the three grades, assessment results and conclusions are presented.

Introduction

Much has been written recently about the loss of manufacturing jobs in the United States. The Indiana Business Review¹, a quarterly publication of the Indiana Business Research Center, Kelley School of Business at Indiana University, discussed these issues in its 2005 outlook for all counties in Indiana. In the outlook for Marion County², where the Meridian Kessler neighborhood is located, the review noted that real median family income has dropped 2.7 percent and there is no dynamic growth in the local economy. Additionally, the unemployment rate increased from 2004 to 2005. Adding to this is that in 2003, 51.4% of public school students in Marion County were eligible for free or reduced free lunch and that the poverty rate in Marion County for children under 18 is greater than 18%. Clearly, with falling economic and job prospects, the students in Marion County may benefit from an outreach program that introduces engineering and technology and the associated careers in a fun and engaging atmosphere.

With these issues in mind, a program called Learning with LEGO™s has been developed by the Purdue University at Columbus to introduce technology and teamwork to at-risk and minority elementary school students in the fourth to sixth grades. At-risk participants are identified as those elementary students who are eligible for reduced or free lunch at their school. This
segment of the population, particularly in an urban setting, is not often exposed to the benefits of education in any form after high school. Trapped in an environment of increasing unemployment rates and decreasing income, education at a 2 or 4-year institution represents one avenue for these children to succeed. Similarly, it is important to demonstrate that engineering, math, and technology can be a fun and rewarding career.

Role modeling and mentoring are also key aspects of the program. Many minority and/or at-risk youth have no role models in science, engineering, and technology fields and can benefit greatly from such a relationship. Indeed, at the campus in relatively rural Columbus, Indiana, many students are the first members of their family to pursue post-secondary education. The at-risk and minority youth are targeted in this project to expose them to adults and college students in the engineering and technology fields. To that end, representatives from the faculty and staff of Purdue University at Columbus assisted the students during the workshops.

The partnership established between Purdue University in Columbus, Indiana and the MKNA is the first such relationship between the school and a neighborhood association. Although the neighborhood is located nearly 50 miles from the school, the burgeoning K-12 outreach program at Purdue University in Columbus sought to engage the neighborhood through the St. Joan of Arc elementary school to increase the visibility of Purdue University in Columbus. As a satellite location of the College of Technology at Purdue University in West Lafayette, Purdue University at Columbus endeavors to forge its own identity. While many prospective students and people, in general, are familiar with the Purdue University main campus, the Purdue University at Columbus would like to increase its recognition and enrollment in its own community. Outreach programs like this are critical in gaining community recognition for the Purdue University at Columbus.

Additionally, in the fall of 2005, the mechanical engineering technology (MET) program at Columbus hosted auditors from the Accreditation Board of Engineering and Technology in an attempt to gain accreditation for its Associate of Science. This was the first program at Purdue University at Columbus to make such an effort and the others are expected to follow in the near future. The MET program will know in the fall of 2006 the results of the audit.

Meridian Kessler Neighborhood Association

From their website (www.mkna.org), the Meridian Kessler neighborhood is “a unique neighborhood located just four miles north of downtown Indianapolis. Living here means participating in a very special historic neighborhood that is both racially and socio-economically diverse. Many different types of housing, from magnificent mansions to moderately priced smaller homes to vintage apartments, are all available with many choices in between. Meridian-Kessler embraces a friendly, small-town atmosphere where neighbors show genuine concern for one another. In Meridian-Kessler, you can take a walk with your child and your pet and know your neighbors you see along the way. You may receive a get well card from your banker, walk over to see your pharmacist for a prescription, visit our new local library or ride your bike along the Monon Trail to the State Fairgrounds. Living here is likely to mean that you can enjoy a satisfying, comfortable life in friendly, secure and beautiful surroundings.”
The Meridian-Kessler Neighborhood Association “was formed in 1965 by a group of residents ‘deeply devoted to our area and to justice.’ The purpose of the association was, and is, to bring about a closer relationship between all people, welcome new residents and businesses, monitor zoning and guard against illegal conversion of single-family housing, maintain quality schools in the area, and provide adequate municipal services for all residents.” One of the MKNA goals is to support “school, church and social service programs.” With this in mind, representatives from St. Joan of Arc school, a private pK-8 school with an enrollment slightly more than 250 students, and MET faculty from Purdue University at Columbus contacted the MKNA about submitting a grant request for the project.

Partnership Agreement

The Learning Pulleys with LEGO™s workshop uses LEGO™s to introduce technology and develop skills such as measuring distances in both the English and metric unit systems while employing simple math skills. The LEGO™ set used in the workshop is the Pulleys Mini Set (product ID W779614) available from www.legoeducation.com for $19. The grant from the MKNA for $880 allowed for the purchase of 45 sets for use at the school. Representatives from Purdue University at Columbus, primarily those associated with the mechanical engineering technology program, agreed to conduct the 3 hour workshop at the school during school hours (8-11am). After the workshop, the participants were allowed to keep the LEGO™ sets and take them home. At the website, the Pulleys Mini Set description states that “students build and work with models to investigate fixed pulleys, movable pulleys, and belt drives”. It includes:

- Two building cards with step by step instructions
- Sturdy plastic storage case with clear compartmentalized tray
- Pictorial parts list to make clean-up and inventory simple

Participants

Representatives from the school and the Purdue University at Columbus determined that the workshop would be conducted for the fourth, fifth and sixth graders at St. Joan of Arc school. Logistics and class numbers dictated that the fifth and sixth grade classes would be combined for the workshop while the fourth grade class would remain separate from the older students. Also, every student had their own set rather than two students sharing a set. There appeared to be a nearly equal mix of boys and girls.
Workshop Organization

The organization of the workshop is based on the Pulleys Teacher Guide, which can also be purchased at [www.legoeducation.com](http://www.legoeducation.com) for $7. The guide contains activities for “exploring concepts, investigating principles, and problem solving.” Also listed in the guide are objectives that state that “after performing activities in this booklet, students will be able to:

- Define a pulley as a wheel with a grooved rim for a belt or cord which can transfer force or speed.
- Build a model which will increase speed.
- Build a model which will increase force.
- Arrange pulleys so that the driver turns in the same direction as the follower.
- Recognize that the turning ratio of one pulley to another is determined by the size of the pulleys.
- Build a model that will transfer force at a 90-degree angle.
- Have fun with pulleys!”

Before beginning the session with the LEGO™s, the students are asked to complete a pre-test that was developed by the MET faculty at the Purdue University at Columbus. The students are asked only to indicate their gender on the test. The same test is administered after the workshop to try to assess learning.

The introductory exercises of the workshop include building several simple machines that familiarize the students with a pulley wheel.

- Direction of rotation – Students build two pulley wheels of the same size and connect them with a rubber band. A handle on one of the wheels, called the driver, is turned and participants see that the other wheel, called the follower, turns at the same speed and in the same direction. By gripping the follower and turning the driver, the students also see that the belt is slipping.
- Changing direction of rotation – The previous model is modified by crossing the belt, thereby forcing the follower to turn in the opposite direction of the driver.
- Decreasing speed – The first model is changed by substituting a smaller wheel for the driver. While the smaller wheel turns many times, the larger wheel may turn only once, illustrating the effect of gearing down to decrease the speed of the follower.
- Increasing speed – The handle is moved from the smaller wheel to the larger wheel resulting in a large driver and a small follower, showing the effect of gearing up.
- At an angle – The follower is turned 90 degrees to the driver demonstrating flexibility in belted systems.
- Compound belt drives – Two more wheels – one small and one large - are added to the model and are connected with the other wheels using two more belts (rubber bands). This created a compound belt drive and demonstrated even more severe gearing up or down.
- Fixed pulley – A fixed pulley model is built showing that force required to lift an object can be oriented to a more convenient angle.
• Movable pulleys – A second movable pulley is added to the fixed pulley from the previous step to produce a block and tackle, allowing the students to experience that less force is required to lift a load but that the string needs to be farther compared with the single pulley.

Face Model

Following the introductory exercises, the participants build a model using building card 1 from their pulley set. This model, shown in Figure 1, helps students to understand belt drives, gearing down, compound belt drives and changing the direction of rotation. Students are asked questions related to gearing up or down, moving the belt from smaller to larger wheels and crossing the belts. Finally, students are able to add a face and mouth to produce a fun picture.

Pulley Model

Building card 2 directs the participants to build the pulley system seen in Figure 2. Initially, the model includes no way to prevent the pulley wheel from turning in the reverse direction, allowing the string to unwind and the load to fall if the handle is not securely held. A slight modification prevents this rotation, creating a pawl and ratchet arrangement and keeping the load from falling. A final adjustment demonstrates how it’s easier to lift a load but that more turns are required to lift it a specific height when compared to a fixed pulley.

Problem Solving

The teacher’s guide also includes several problems that the students are challenged to solve with no directions on how to build the model. The first involves designing and building a conveyor belt system that will avoid having packages pile-up. The second asks students to design and construct a boat mover that could be used to pull a boat. Pictures of both are shown below.
Assessment of LEGO™ Activity

The ten-question test shown at the end of the paper was developed by MET faculty and used for the pre and post-test to assess participants’ learning. Figures 5-7 compare the results between the boys and girls of the fourth through sixth grades. Results were not differentiated by grade but only by gender. Note that the y-axis on figures 5-6 represents the percentage of students who answered that question correctly while the x-axis represents the question number.

Performance on the pre-test was really pretty good on 8 of the 10 questions for both genders, with boys scoring slightly higher on 7 of the questions. For the post-test, however, the girls scored better than the boys on 6 of the questions but the more interesting observation is that there is no distinct improvement on the post-test. Figure 7 shows the percent improvement on each question for the boys and girls. A positive number on Figure 7 indicates that more members of that group answered the question correctly on the post-test while a negative number means that fewer members answered the question correctly. On six of the questions, fewer boys answered correctly on the post-test than on the pre-test. Conversely, more girls gave correct answers for six of the questions on the post-test than on the pre-test. Previous work by one of the authors showed similar results in that the girls, based on pre and post-test results, learned more during the workshop than the boys.

Observations

As with previous workshops conducted by the authors, the students in the fourth, fifth and sixth grades seemed to be interested in participating in the workshop and were engaged for the full three hours. Teachers of the three classes involved also participated by helping the students who needed assistance. Combining the fifth and sixth grade classes meant that the students in that room had little space to do their work and while this may not have hindered their performance or enjoyment of the workshop, this issue should be addressed in future sessions. The thin string provided with the LEGO™ pulleys set proved to be difficult to handle and keep on the pulley wheels.

Conclusions

This paper reported on a unique partnership between Purdue University at Columbus, Indiana, the Meridian Kessler Neighborhood Association in Indianapolis, and St. Joan of Arc parochial school. A grant of $880 was received from the neighborhood association to purchase over 40 Pulleys Mini Sets from LEGO™ which were used in a workshop for students at the school. Conducted by faculty and staff from Purdue University at Columbus, the workshop intended to present science, technology, engineering, and math in a fun and interesting way that included hands-on exercises to build and test LEGO™ models.

Assessment of the activity proved inconclusive as test scores on pre and post-tests improved only slightly for the girls and did not improve at all for the boys. This was disappointing but a redesign of the assessment instrument for future workshops is likely necessary. Other considerations for future workshops would be to provide adequate space for the participants and finding an alternative to the thin string provided in the kit used by participants for the pulleys.
Bibliography


2. County Profiles, A component of STATS Indiana, Indiana Department of Workforce Development, Maintained by Indiana Business Research Center at Indiana University’s Kelley School of Business, [www.stats.indiana.edu](http://www.stats.indiana.edu)


Exploring LEGO™s with Pulleys Pre-test and Post-test

1.) A pulley is a wheel with a grooved rim that can be used to transfer:
   a.) force to turn another wheel
   b.) speed to turn another wheel
   c.) either a.) or b.) above

2.) A crane uses one or more pulley wheels to:
   a.) increase the size of heavy objects
   b.) raise heavy objects

3.) Two pulley wheels can be connected by:
   a.) a piece of cord
   b.) a belt
   c.) either a.) or b.) above

4.) Two pulley wheels are connected by a belt. If pulley wheel is turned then the belt causes the pulley wheel to:
   a.) translate
   b.) rotate or turn

5.) Two pulleys connected by a crossed belt arm turn in the:
   a.) same direction
   b.) opposite direction

6.) A small driver makes a large follower turn:
   a.) faster
   b.) slower

7.) A large driver makes a small follower turn
   a.) faster
   b.) slower

8.) The direction of rotation of a pulley can be changed by 90 degrees when using:
   a.) a belt drive
   b.) additional LEGO™ models

9.) A fixed pulley can change the direction of lifting force to a more convenient angle. An example of this would be:
   a.) a bicycle pedal
   b.) a Venetian blind or a flag pole

10.) A movable pulley can be used with a fixed pulley to lift a load with:
   a.) more effort than with a fixed pulley alone
    b.) less effort than with a fixed pulley alone