

## **Technology Breathes New Life into a Dying Outreach Program**

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### **Abstract**

For the past 27 years, Minnesota State University Moorhead and the Fargo-Moorhead Engineers Club have teamed up to provide a unique outreach program to students in west-central Minnesota and eastern North Dakota – a Toothpick Bridge Competition. Held in conjunction with National Engineers Week, students from grades 1 to college build a bridge using only toothpicks and glue to meet a limited set of specifications. They bring their bridges to the MSUM campus and load them to failure. The strongest bridges, determined by dividing the load held by the weight of the bridge, are awarded cash prizes. Some of the prizes are awarded by grades: 1<sup>st</sup> – 6<sup>th</sup>, 7<sup>th</sup> – 9<sup>th</sup>, 10<sup>th</sup> – 12<sup>th</sup>, and college.

Over the past 10 years, involvement in the program has been decreasing. Where the competition had drawn as many as 160 participants, as few as 14 now compete. MSUM and the FM Engineers Club were considering whether to continue with the program. Fortunately, technology appears to be breathing new life into the program. A new web site, hosted by MSUM, offered a wider range of information to teachers and participants. A listserv of science and math teachers in the area, maintained for other outreach programs at MSUM, allowed the web link to e-mailed to hundreds of teachers in scores of area schools.

The 2002 competition involved students from 4 schools who had not previously participated, and several more made initial contacts. With proposed upgrades to the website, it appears the program is on its way to new growth and continuing success.

## INTRODUCTION

A 2002 report by the National Academy of Engineering and the National Research Council<sup>1</sup> begins with the ominous statement, “Available evidence shows that adults and children have a poor understanding of the essential characteristics of technology, how it influences society, and how people can and do affect its development.” Compounding the problem is a general misunderstanding of who engineers are and what they do. Data from the National Science Board<sup>2</sup> indicates that “61 percent of respondents did not consider themselves well informed about engineering and engineers”. Apparently, that lack of information has been long-standing. In 1951, the National Society of Professional Engineers (NSPE) initiated National Engineers Week (E-week) with two goals: to share the excitement of engineering and to build public awareness of how engineering benefits society<sup>3</sup>.

For the past 27 years, the Fargo-Moorhead Engineers Club (FMEC), in its role as Chapter 4 of the North Dakota Society of Professional Engineers, has sponsored a Toothpick Bridge Competition in partnership with Minnesota State University Moorhead (MSUM), as an outreach event in connection with E-Week. The purpose of the event is to engage students in thinking about engineering and engineering design. For the student, the goal is to build the strongest structure that meets a specific set of constraints. The event is the culmination of their work – each of the bridges is tested to failure, with the strongest bridges earning cash prizes provided by FMEC. For the sponsors, the goal is to engage as many students as possible in a learning activity that: A) requires the student to design to meet constraints, B) allows for interaction with practicing engineers, and C) offers tangible rewards for design success.

## HISTORY

In 1974, Charles Martin, MSUM's director of Pre-engineering and a member of FMEC, proposed the concept of a competition as a part of the club's E-Week activities. The competition rules would define a set of design specifications and identify the criteria to be used in evaluating the success of each design. MSUM would provide site support, promotion, and communications with area schools. FMEC would provide cash prizes, workers and judges for the competition, and guest speakers where requested. The first competition was held in February of 1975, and has been held annually since then. The competition rules and procedures have changed little in that time.

Each year in early January, the competition coordinator at MSUM sends out notices, rules, and registration materials to interested teachers, parents, and students in the region. The rules define the limitations on design required for each bridge to compete for the cash prizes. For 2002, each bridge was required to have a mass of 85 grams or less, and to freely span a distance of 56 cm. The bridges could be made using only round wooden toothpicks and white aliphatic resin glue (such as Elmer's Glue-all<sup>®</sup>) or a yellow carpenter's glue (such as TiteBond<sup>®</sup>). The toothpicks had to be used as they came from the box – no fraying or splicing of ends was allowed, and the tips of the toothpicks were not to be trimmed off, with one exception: where the bridge made contact with the testing table and the load plate, the tips could be trimmed to make solid contact.

The testing table and weights shown in Figure 1 have been in use since the competition's inception. The table has a 30" (762 mm) high welded steel frame supporting a 42"x 32" (1067 mm x 813 mm) plywood top. The center of the table is padded with carpet to soften the shock of the falling weights. A 30" (762 mm) length of 1x4 and 2x4 dimensional lumber are attached to the inside of each of two 34" (864 mm) lengths of 3x3x1/8 steel L-section, to form abutments.



Figure 1 – Competition Table in Use

Each abutment can be clamped to the table at any point along the table's length. When students elect to build a bridge with a horizontal bottom chord, the required span is developed by clamping the abutments with the span length between them, and resting the bridge atop the abutments. When the student builds a bridge that incorporates the span, the abutments can be clamped in place so as to make direct contact with the base of the bridge, providing lateral thrust support.

Each bridge is weighed and inspected for compliance with the rules before loading begins. The students place their bridge on or between the abutments as required. They place a 9" (229 mm) wooden loading disk on the top of their bridge. They then place lead weights atop the disk until the bridge fails. Failure is defined as the point when the bridge breaks or tips so as to dislodge the weights, or when any part of the structure touches the table surface so as to reduce the span below the minimum required. Judges provided by FMEC record the total weight supported before failure, and determine the strength of the bridge by dividing the weight

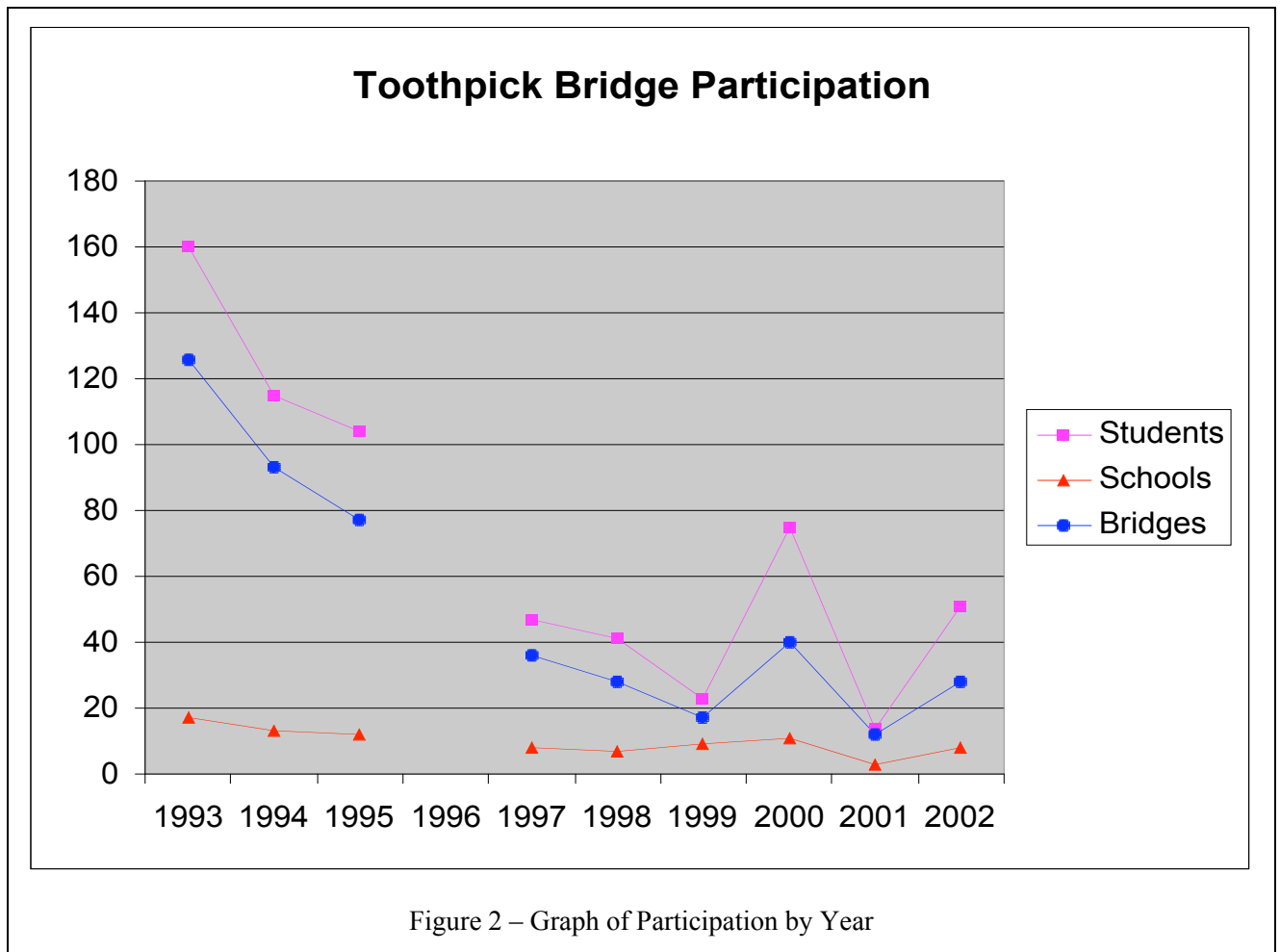
supported by the weight of the bridge. Cash prizes are awarded by FMEC based on the strength of the bridge. In 2002, the prizes awarded were: 1<sup>st</sup> Overall - \$100, 2<sup>nd</sup> Overall - \$75, 3<sup>rd</sup> Overall - \$50, Next high in each grade class (1<sup>st</sup> – 6<sup>th</sup> grade, 7<sup>th</sup> – 9<sup>th</sup> grade, 10<sup>th</sup> – 12<sup>th</sup> grade, and college) - \$25. In addition, the judges select one bridge to receive a \$25 prize for best overall appearance, both in design and in construction methods.

Some designs have been remarkably successful. The overall winner for 2002 supported 202.9 pounds (92.0 kg) with a strength ratio of 1146 lb/lb. In 1993, a student built a bridge that supported 391.6 lbs (177.6 kg), with a strength ratio of 2280 lb/lb. That record has not been surpassed.

In the first years, the competition was held in an MSUM auditorium, but in the early 1980's it was moved to a shopping mall court to develop more community interest. At that time, the competition drew as many as 120 bridges, some from schools more than 90 miles from Fargo-Moorhead. The competition has always been held in the evening to allow travel time for the competitors. This caused a conflicts with the malls, because the large number of entrants often could not be loaded before the mall closed. In 1990, when the Holiday Mall remodeled and their courtyard space was no longer available, the competition moved to the ballroom of the Comstock Memorial Union at MSUM. This facility provides adequate space, seating, staging and other facilities, but eliminates the opportunity for passers-by to drop in on the competition.

#### DECLINING PARTICIPATION

In the last 10 years. Participation in the competition has fallen dramatically. Figure 2 shows the trends for number of students participating, number of bridges entered, and number of schools represented. It shows that in 1993, 160 students representing 17 schools brought 126 bridges to the competition. In 2001, only 14 students, from 3 schools, entered a total of 12



bridges. As this trend became apparent, FMEC and MSUM officials began to search for reasons for the decrease. Interviews with teachers and students at the competition, and with other science teachers throughout the region offered several possible causes:

- More events compete for student time each year.** The February competition date, set to occur during E-Week, requires the students to be planning and building their bridges at the same time they are working toward MathCounts, Science Olympiad, JETS competitions, and sports tournaments, among others. If they view the competition as a time demand in addition to those required by class or team events, they may not choose to participate.

- **Participation is sometimes limited by available resources.** Many schools have limited resources for coaching time and travel expense. With the increasing number of events in February, some schools have elected to eliminate “optional” events.
- **Information has not reached a number of students and teachers.** Each year, the competition coordinator at MSUM prepares and mails posters, rules, and registration information to teachers, school principals, students, and parents who’ve expressed interest in the competition. Because of the high printing and mailing costs, the list is limited to those who have previously participated, those who have made a contact asking for the information, and the science teachers in a select group of targeted schools. Anecdotal evidence indicated that much of the information was being misdirected. The teacher addressed may have moved, and the information packet simply thrown away. In some cases, the information went to a principal who announced that anyone interested could see the packet in his/her office, so the posters and registration information never made it into the hands of the students in the school. A number of teachers said they had students who were interested, but they didn’t learn the details in time to participate that year.
- **Teachers didn’t have time to add any new content or activities to their regular load.** Many coached teams for other extra-curricular activities, and did not have time to help their students plan and build bridges, nor the time to bring them to the competition.
- **Students focused their time and energy on events supported by their teacher and their school.** In 1993, more than half the students came from 5 schools. In each case, the teacher made participation in the event a part of his/her grading scheme, arranged transportation, and came to the event to support his/her students. In most of those

schools, with the competition a part of the curriculum each year, the students had a history of participation. Some had helped siblings build bridges. Others who built a bridge as a requirement for a 9<sup>th</sup> grade physical science course elected to build bridges again in years with no class requirements. Registration information showed the same students entering bridges for 2, 3 and sometimes 4 consecutive years. In contrast, when a student built their bridge independently of a class, they often entered for that year only, and their school often was not represented in subsequent years.

## ALTERNATIVES

Given the information above, MSUM and FMEC officials identified three things that might be done to increase participation:

1. **Increase the level of cash awards.** The award amounts have not changed in the 12 years the author has served as MSUM's competition coordinator. FMEC officials considered increasing the award amounts as an incentive to more students. However, interviews with students and teachers indicated that, while the cash awards provided incentive, they were not the primary reason students participated, and increased awards were unlikely to provide a solid return. FMEC elected not to increase award levels. This decision will be reviewed following the 2003 competition.
2. **Disseminate information to a broader group of teachers and students.** The problem here is twofold – providing the level of information required, and reaching the people who need it. The primary means of announcing the event was the mailings described above, and news releases to local papers listing a contact phone number. The greatest difficulty was selecting who from the database of regional teachers and administrators should receive the mailing, and how many of the pieces each should



receive. In 2000, MSUM provided funding and staff to develop an expanded mailing, using addresses for science and math faculty throughout the MSUM service region. The 2000 mailing included printed posters, a cover letter, rules, and registration forms. The results were dramatic – the first increase in participation in a number of years. The results were encouraging, but the cost of printing and mailing turned out to be prohibitive for continued use. When that level of contact was not maintained, participation dropped back to or below previous levels. What was required was a regular, affordable process of making a wide range of information available to anyone who might need it, and a means of informing the users that that information is available.

3. **Provide assistance in incorporating the competition into science curricula.** The information at hand indicates that schools that make the competition part of the curriculum bring more students, and that those students often return in subsequent years. Teachers who chose not to participate or not to incorporate the competition, when interviewed, often indicated they were not sure how to add another event to an already full schedule. Therefore, one approach to increasing participation might be to provide support for teachers who choose to make the competition a part of their curriculum.

## NEW TECHNOLOGY

The solution for both alternatives 2 and 3 was to make use of computer technology. MSUM agreed to host a website for the competition. The site can be accessed at [www.mnstate.edu/bridge](http://www.mnstate.edu/bridge). The home page for the site is shown in Figure 3. The site provides viewers with rules for the current competition, tips on bridge construction, and links to sites

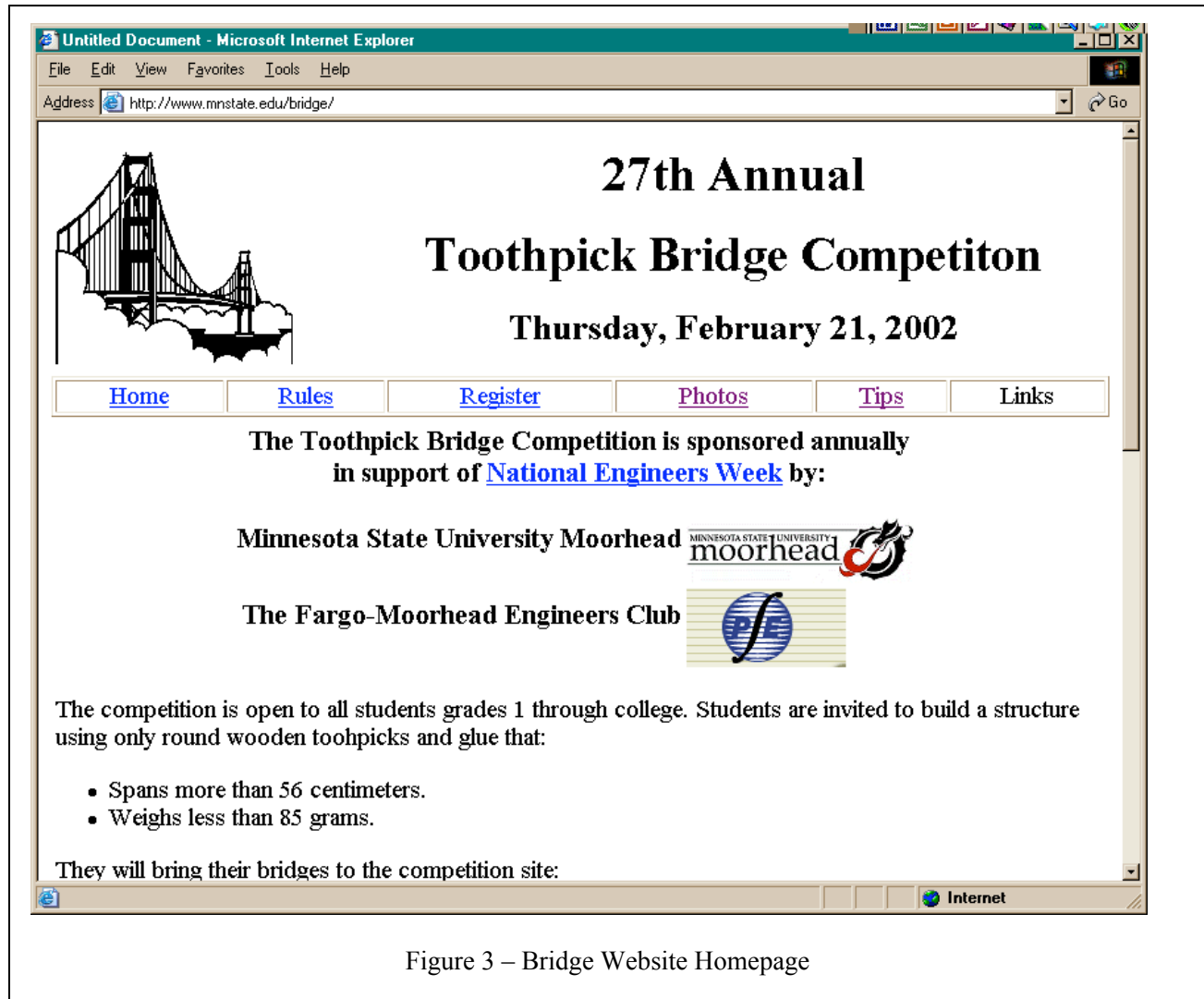


Figure 3 – Bridge Website Homepage

related to bridges, trusses, structural design and other competitions. Because many first-time bridge builders ask for help in selecting a design or guidance on constructing a bridge, the site includes photos of past winners, and a series of photos provided by a group of students documenting the process they used to construct their bridges. More than half the bridges pre-registered for 2002 used the site to register.

Having selected the information to provide, the next step was to inform the target audience of its availability. The College of Social and Natural Sciences at MSUM maintains a database of names and e-mail addresses for science and math teachers within the MSUM service

region in west-central Minnesota and eastern North Dakota. Those names were used to create a listserv containing more than 950 recipients. A brief e-mail outlining the event and providing the web page address was sent to each member, along with a request to forward the information to other teachers the recipient thought might be interested.

## RESULTS

Although only one year's data is available, the results have been positive. The number of students participating went from 14 in 2001 to 51 in 2002. Those students came from 8 schools, compared with 3 in 2001. Four of those school had never previously participated in the competition, and the teachers all indicated they planned to return in 2003. In addition, contacts were made by 3 new schools who needed more time to incorporate the competition in their schedule, but hoped to participate in 2003.

## FUTURE PLANS

The results indicate a successful transfer of information to teachers and students using the website. However, more contacts would only add to the success of the site, and new features may address other possibilities for growth. MSUM plans a number of changes for the 2003 competition:

- **Wider distribution of the website URL.** The news release about the event will be submitted electronically to a large number of regional newspapers, and will include the website address. Major search engines such as Google and Lycos will be advised of the site. Printed media with the URL, such as bookmarks or cards, can be distributed to students as a part of other outreach events during the year.
- **A button to add or remove your name from the listserv.** Any student, teacher, or parent who find the site could click on the button to add their name and e-mail address to

the listserv. They would receive regular electronic updates on current and future competitions. Those who no longer want these updates could choose to remove their information from the listserv.

- **Support for teachers who wish to incorporate the competition in their curricula.** In the short term, MSUM hopes to post curricula provided by participating teachers as a guide to making the competition an active part of regular classroom activities. One participating teacher has offered to make his curriculum available on the site. Others will be recruited in the near future. For the long term, MSUM faculty are exploring options to work with science educators enrolled in the Masters of Curriculum and Instruction program to develop new curricula. This material may be incorporated into specific sections of a high school Physics curriculum, or may be used to help document the completion of science standards.

## CONCLUSION

The Toothpick Bridge Competition was created as an outreach effort between MSUM and FMEC. As is typical for such efforts, interest has dwindled over time and participation has been waning. The use of a website and listserv to support the activity appears to offer new hope for continuing success.

## REFERENCES

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- [2] National Science Board, *Science and Engineering Indicators 2002*, NSB 02-Chap. 7
- [3] *E-Week's Anniversary Is a Golden Opportunity for PEs to Shine*, Engineering Times, Vol. 23, No. 2, February 2001