



THE K'NEX BRIDGE PROJECT

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The K'Nex Bridge Project is an engineering education activity conducted annually at Big Creek Elementary (Middleburg Heights, Berea City School District) since 2000 and at both Smith Elementary School (Berea) in 2001 and Homer Nash Kimble Elementary School (Madison) in 2003. As of June 2007, just over 1,000 fourth and fifth grade students have participated in this exercise that combines elementary school science, math, and team skills with the practice of bridge engineering.

This K'Nex Bridge Project began at Big Creek Elementary during the 1999/2000 school year. Four local civil engineers¹, each active in bridge or roadway construction and who have children who are either former or current students at Big Creek, helped develop this activity with Big Creek's administration, 4th grade faculty and PTA. In order to allow the students to fully comprehend the thought process of bridge engineering, the bridge project is divided into two sessions with the students. The first session serves as an introduction to bridge engineering while the second meeting is the actual bridge building exercise that allows the students to apply the engineering principles.

The First Session

During the first session, the engineers typically meet with two classes (about 50 to 55 students) for 90 minutes. The first 30 to 45 minutes are used to discuss the three specific aspects of bridge engineering and are as follows:

1. The Civil Engineer's Background – where the engineer(s) each went to college, what topics were studied, how he became a P.E. (professional engineer), where he works and what he does.
2. General Bridge Engineering Practice – names of bridge components (piers, abutments, superstructure, deck), inspection practices, funding issues for rehabilitation or replacement, and the three basic bridge types (beam, arch and suspension).
3. How Bridges Work –The forces applied to bridges, tension, compression and bending and how these forces influence the three basic bridge types, demonstrated with various models, props and student participation.

¹ Randy Over, Brian Driscoll, Brendan Finn and Bill Vermes.

For the remaining 45 minutes, the students are placed in groups of 5 to 6 each. Each group is given a bridge plan depicting various bridge prototypes (suspension, trestle, arch and cantilever) included in the K'Nex bridge kits. This exercise gives the students some experience at building from plans, practice at using the parts and understating the patterns of the connections. The engineers and teachers are encouraged to oversee the group and assist if needed. The final ten minutes are used to place weights on these bridges and discuss how the structures fail or stand. These bridges will hold from almost no weight to about 15 pounds.

The Second Session

The second visit usually is scheduled about two weeks after the first one. This time, the students are asked to make their own bridges under the following constraints:

1. 14-inch minimum span length,
2. 6-inch minimum clearance, and
3. a successful bridge needs to hold 20 lbs.

Originally, this session has been conducted in three-90 minute sessions in one school day, with two classes in each session. However, this is the most challenging and time-consuming endeavor, and following discussion with the 4th grade teachers and school administration, the current format has this final exercise conducted in two sessions, each two hours long and with three classes per session. The additional class has meant that more space is needed within the school to permit more bridge-building stations. Teams also now have up to seven students, increasing the likelihood of personality conflicts within each team. Most groups do build a competitive bridge, and the variety of designs produced demonstrates that in the real world, often there is more than one answer to any problem (Photos 1 & 2).

As a means of incorporating economy and math skills, groups that finish their bridges with time to spare are asked to calculate the cost of their bridges. Each connector or rod has unique lengths or connecting abilities, and thus unique unit costs. The students are asked to develop as a group a method of determining the quantities of the various components in their bridges, placing these quantities on a paper spreadsheet and then calculate the total cost of their bridge with multiplication and addition. Though each group does not complete this exercise, this task does emphasize an important facet of engineering. Engineers design bridges using as few parts as necessary, to be as affordable as possible. One lesson the students learn is that if a bridge engineer used too few parts, the bridge will fail and it is better to have an over-designed bridge than one under-designed. Overall, the best design is declared as the one bridge that supports 20 pounds for the least cost (Photo 3).



Photo 1 - One Student-Designed Bridge

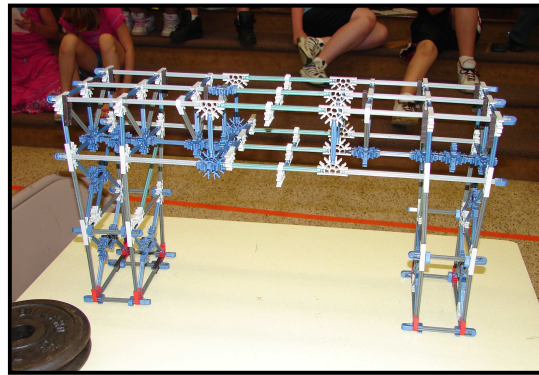


Photo 2 - ... and a Completely Different Design

Costs and Coordination

Funding for the K'Nex Bridge project came from a \$500 grant from the ASCE – Cleveland chapter and a \$500 Eisenhower grant obtained by Big Creek principal Al Feikle. The school bought 6-medium bridge builder K'Nex sets and 3-large sets for about \$850. Combined, these sets contained over 4,000 individual parts in the traditional K'Nex color scheme. After seven years of use, several commonly used connectors had worn or broken. Big Creek Elementary has purchased one additional *educator* K'Nex set last year, however, the color scheme of these parts differs with the parts of the retail sets, and the two color styles should not be mixed.

Over the past decade or so, many schools have conducted spaghetti bridge or balsa wood bridge competitions for middle school and high school students as a means of introducing engineering concepts. The costs for these materials and glue are relatively small compared to K'Nex kits. However, the true advantage of making K'Nex bridges is that the construction times are much shorter than spaghetti bridges or balsa wood bridges, and any necessary modifications can be identified and made quickly. K'Nex bridges are also larger, and when load tested properly, any inherent deficiency can be pointed out by the engineers before collapse occurs. With repeated use of the parts, the K'Nex Bridge Project has become a very economical use of school and donor funds.

The K'Nex Bridge Project continues to have the strong support of the Big Creek administration and teachers. Scheduling typically starts in January or February, looking for mutually open dates among the 4th grade classes, the overall school schedule (for room availability) and the engineers. The sessions typically are conducted in April and early May, after the Ohio proficiency tests have taken place. An exception occurred during this past school year as the last meeting was conducted after Memorial Day for the first time. This may have resulted in a nice end of the school year activity for the students and teachers.

An added benefit of having the bridge project later in the school year is that the 4th grade student, typically 10 years old, experiences noticeable maturing in his or her personality during the school year. As an aside, the K'Nex bridge project is better suited

for the personalities of 5th grade students, however the bridge building exercise of this project generally fits the 4th grade science curriculum better than that of the 5th grade.

Conclusion

After eight years of practice and hundreds of creative bridge designs, the K'Nex Bridge Project benefits all parties involved. Teachers are given real life applications regarding the math and science they teach their students and civil engineers have a chance to demonstrate the satisfaction and challenges of their profession to prospective engineers. Most importantly, though, elementary school children participate in a fun, hands-on activity that shows each student how science, math and civil engineering can be both enjoyable and useful.



Photo 3 – Local Bridge Engineer Load Testing a Student-Designed Bridge