PARTNERING A PATH FOR WOMEN IN ENGINEERING

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ABSTRACT

A partnership between Hewlett-Packard and Northern Colorado school districts was formed to promote systemic change in math and science teaching methods. Hewlett-Packard donates the time of a woman engineer one day a week to train and mentor K-12 teachers in math, science, and technology. The focus is increasing student achievement in, and attitudes toward, math, science and science careers. Results indicate that the partnership is working from three points of view: schools (K-12), HP management, and the engineer.

INTRODUCTION

Three people needed to solve a problem: Educators are required, through state content science standards, to teach students how science and technology are used outside school; high-tech industry needs a larger and more diverse pool of qualified engineering candidates from which to choose; and a woman engineer left engineering to teach and wanted to be able to combine her desires to teach, influence math and science teaching methods, work as an engineer, and act as an ambassador to girls in engineering.

A position was created which addressed the needs of all three. As part of a hiring contract, Hewlett-Packard agreed to donate the time of the above engineer to Northern Colorado K-12 school districts. On a yearly basis, the engineer provides results to HP that measure the partnership. A K-12 professional staff development coordinator provides staff development opportunities for teachers for training and mentoring by the engineer.

Engineering Position

In order to form this partnership, there first had to be a engineering project manager agreeing that for this position, during the school year, the engineer would be available for engineering projects 80% of the time and an opening for a full-time engineering position for which the engineer was qualified had to exist.

There was a requisition open for a full-time engineering position in a manufacturing development organization for which the engineer was qualified. Concerns by the project manager included availability to customers and continuation of other job objectives and schedules. Several things put in place to alleviate concerns included careful selection of a day to donate to K-12 (assuring maximum availability across all production shifts); checking voice mail when off-site with the partnership (and responding to emergency manufacturing problems that arose); and a clause in the hiring contract stating that should business needs change, the engineer can be given 4 weeks to go full time engineering, find another manager willing to support this, or choose to leave. In addition, the K-12 partnership was included in objective reviews along with engineering responsibilities as part of the job requirements for this position.

A tremendous amount of flexibility was required by the engineer, manager, and teachers. Some weeks it was necessary to trade the donated day (because of engineering and/or K-12 needs); some weeks, it was impossible to donate a day. Because of tight technical resources and difficulty hiring in the second year of the partnership, the engineering workload was heavy. While HP management remains committed to K-12, at times it would have been easier to have the engineer on-site 5 days a week. In the second school year of the partnership, at the most, 15% of the engineer's time was spent in this partnership because of increased manufacturing engineering demands. Overtime hours were spent by the engineer to satisfy requirements of both positions.

Teacher Participation

The Weld County professional staff development coordinator arranged for teachers who were willing to participate. A mix of veteran and new teachers from both elementary and secondary schools was targeted.

A key concern of teachers was that this partnership did not require additional time away from planning or classroom activities. In addition, it was difficult to ask teachers to have a "control" classroom (where no special activities were done) for data collection: it requires the teacher to have two sets of activities, and can be frustrating when some of the activities are reacted to so positively by students.

PARTNERSHIP ACTIVITIES

It was desired that all activities met Colorado state and district math and/or science content standards, and that the majority of activities were actually done by teachers in the classroom. This way, when the engineer left, the teacher still had the tools necessary to do the activity with the class.

Three key activities were a science career workshop for young women, a Science-Technology-Society unit at a middle school, and an spatial reasoning unit at an elementary school.

Science Career Workshop

A science career workshop, meeting Science Content Standard #5[1], was organized and presented to girls at a rural middle school in Northern Colorado. There were three science careers represented at this workshop: engineering, microbiology (two specializations), and range ecology. Each girl attended two sessions of her choice. Each 45 minute session was run by a woman engineer or scientist who works in that particular career. In addition to information on what is required to do this job, each session included a hands-on activity for the girls that was representative of this career.

A survey was given to the girls immediately before and after the workshop. The questions in the pre- and post-survey were identical:

1. Do you know what is required to become a scientist or an engineer? (1 = No, 6 = Yes)
2. Could you become a scientist or an engineer if you wanted to? (1 = No, 6 = Yes)
3. What careers are you interested in? Name as many as you want.
4. How many years of math do you intend to take in high school? (1 to 4 years)
5. How many years of science do you intend to take in high school? (1 to 4 years)

The survey results are shown in Figure 1. Figure 1a shows the average response to each of questions #1, 2, 4, and 5. Figure 1b shows the number of times one of the represented science careers (plus "Don't Know") was written in response to question #3. There was significant difference in Question #1 and in the number of responses of each of the represented career choices before and after the workshop. This indicates that interest in these careers was ignited in the girls during the workshop, as well as their confidence in understanding what was required to work in the sciences and engineering.

Figure 1

Young Women's Science Career Workshop

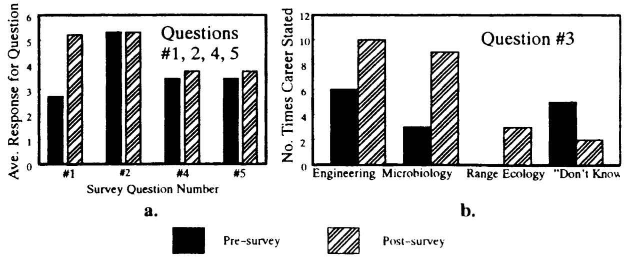


Figure 2

Spatial Perception, Grade 3

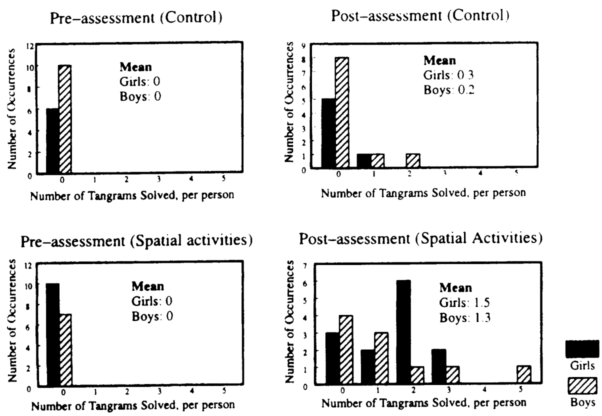
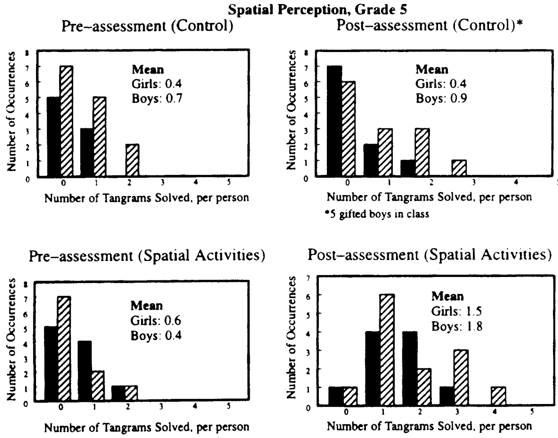


Figure 3

Spatial Perception, Grade 5



Science-Technology-Society Middle Unit

The purpose of this unit -- to investigate how science, technology, and human activity are interrelated and how they affect the world -- is identical with Colorado State Science Content Standard #5[1]. There was data from an STS program in Iowa that indicated that both boys and girls do better both in science content and in attitude towards science with this approach.[2,3]

The HP engineer, together with two science teachers at a middle school, created the activities and assessments for this unit. During the course of the school year, the two teachers presented STS activities to students. These activities included a lesson on inventions, guest speakers form the community on careers, informational interviewing and other job hunting and budgeting exercises, and an Invention Convention where students invented something and displayed their invention. Students were given a survey at the beginning of the school year and again after all the STS activities. Teachers had tried to maintain "control" classes, in which some activities were not done. All students did the Invention Convention. The survey was similar to that in the career workshop, asking about career interests, amount of math and science in high school, plus questions on how math and science is used in careers.

Results are shown in Table 1. This graph shows the difference (after - before) in response on the surveys after the STS unit. Data indicated no difference between the control class and non-control classes. It was very difficult to isolate classes -- all students participated in the Invention Convention and presented their project to the class. Overall, there was an increase in answers to most questions by all students, particularly those where students listed ways in which math and science were used in careers. A survey was also given to the two participating teachers. They indicated a student enthusiasm and continuation of students on their own researching career opportunities in the non-control classes. The assessment may need to be revisited to measure this.

Table 1
STS Survey Results

	Control		**STS†**	
Question	Boys	Girls	Boys	Girls
4a	+0.5	+0.4	NC*	-0.1
4b	+0.3	+0.5	+0.3	+0.3
6	+0.1	+0.4	+0.1	+0.4
7	-0.3	+0.6	+0.5	+0.8
8	-0.5	+0.7	+0.2	-0.1
9	-0.7	+0.2	+0.1	-0.2
A	+0.1	+0.7	NC*	-0.1
B	-0.4	+0.3	+0.1	+0.1

4a. Name 5 careers that use math and science.
4b. In one of those careers, describe how math and science are used.
6. Do you know what is required to become a scientist or an engineer? (1 = No. 6 = Yes)
7. Could you become a scientist or an engineer if you wanted to? (1 = No. 6 = Yes)
8. How many years of math do you intend to take in high school?
9. How many years of science do you intend to take in high school?
A**. Of those who listed a career in science, how many years of math do they intend to take in high school?
B**. Of those who listed a career in science, how many years of science do they intend to take in high school?

† All students participated in Invention Convention. "STS" students participated in career activities.
*NC - No Change
**Interpreted from data, not questions on the survey

Spatial Perception Unit

Partnering with the enrichment teacher at an elementary school, research on spatial perception was done. This topic was chosen for four reasons: (1) Spatial reasoning is useful in the physical sciences (which are heavily relied upon in engineering), (2) Initial data were found, indicating that boys may be better than girls at spatial perception because of practice[4]. (3) Spatial perception is part of State Content Math Standard #4[1]. (4) It was useful to be able to measure, and share measurement techniques, the impact of the school enrichment program on student achievement.

The enrichment program consisted of a special resource teacher visiting classes weekly. Four classrooms were chosen for the study: two third grade classes and two fifth grade classes. One classroom from each was a control. All four classrooms were given identical pre- and post-assessments. The assessment consisted of a sheet of Tangram pictures which the students used with Tangram pieces to complete as many as pictures as possible in an allotted time.

In the two Spatial Activities classrooms, the enrichment teacher weekly led spatial reasoning activities through the school year. These activities included symmetry and pattern practice, creating puzzles, and practicing with Tangrams (different pictures than those used on the assessments)[5]. One Tangram practice activity was done with the Tangram answers so students could see the lines between the Tangram pieces on the picture.

The results are shown in Figures 2 and 3. For grade three, in the pre-assessment, no students were able to complete any Tangram pictures. At the post-assessment, the control class (no spatial activities) completed only three puzzles in the entire class. Students in the Spatial Activities class were able to complete, on average, 1.5 puzzles (girls) and 1.3 puzzles (boys). For the fifth grade, there was no change for the girls in the control class, and a slight increase for the boys. There were, however five boys in this classroom that were in the gifted program (pulled out through the year for extra activities) and may have been exposed to spatial reasoning activities. Students in the non-control grade five classroom, however, more than doubled the number of puzzles they could solve. In addition, there is no significant difference between genders. One of the most interesting "qualitative" pieces of data is the comment by a student (that had spatial activities during the year) that on the post-assessment that they could see the lines between the pieces in the post-assessment picture. There were no lines, but the practice with such lines had made it possible for that student to draw lines in their mind.

These results imply that spatial perception can be learned and there is no difference between genders in the ability to learn spatial reasoning activities. In addition, the enrichment teacher was able to learn how to assess her weekly in-class activities. Even in the 30-45 minute/week time spent with students, there was a noticeable difference in ability to solve Tangram puzzles.

For each of these activities, different measurement tools were used. In addition to the presented data from student surveys and assessments, teachers were also surveyed about their role in the partnership. Teachers were asked about student achievement evidence, activities that would not have occurred without the partnership, and continuous improvement. The teachers were excited that students showed enthusiasm about science careers and were hopeful this program would continue. A big key to making this work for them was the amount of direct communication and mutual respect for everyone in the partnership.

CONCLUSIONS

This partnership appears to be working from several standpoints: educators, HP engineer, and HP management. Educators have received teaching and assessment tools to increase student achievement: the HP engineer remains VERY excited about systemic K-12 education changes, while working as an engineer; and HP has succeeded in recruiting and retaining the woman engineer, and meeting K-12 goals of increasing student achievement and science career aspirations. A large key to the partnership success has been flexibility and respectful communication between everyone involved. Follow-up in several years with the participating students will provide data for HP's long term goal of increasing numbers of women studying math and science.

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