"Business-Style" Group Work in a Freshman Engineering Honors Class

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Group work expanded to include a "business-style" approach was introduced into the middle quarter of a year-long physics class for Freshman Engineering Honors students. Voting Machines were used during lectures as a means of strengthening group cohesiveness. Results are presented for end-of-quarter surveys and an "outside of class" project that involved separate interviews with each group.

Introduction:

This work is a first attempt to broaden group work from a learning tool into an activity that couples more strongly to modern-day demands.

Training engineers to work in teams is a goal explicitly stated by the Accreditation Board for Engineering and Technology (ABET) [1]. ABET emphasizes that leaders of industry view teams in a broader sense than facilitating a learning process. "Business-style" groups/teams set up meetings, create organizational structures, divide work, and establish timelines with early-warning milestones and other safeguards to protect against failure. On a broader scale, they also make themselves aware of a variety of associated environmental and other concerns. There is a large body of physics education literature documenting the use of groups as a learning tool [2], but there is less concerning use of "business-style" groups [3].

Longer-term members of the Ohio State University (OSU) Physics Education Research Group (PERG) have experience in education research. A newer member (nwr) has led myriad high-energy physics groups. The authors formed a collaboration to study emphasizing "business-style" groups in the winter electricity and magnetism quarter of a year-long physics course for Freshman Engineering Honors (FEH) students at The Ohio State University.

Forming groups and group activities:

Approximately 65 FEH students were divided into 17 groups that were maintained for the entire 10-weeks. Groups were chosen on the basis of grades for the same course taken from the previous quarter. Each group had a balanced spectrum of grades, with approximately the same average mean as the others. Three students withdrew during the quarter, but no groups were changed. Students were offered a chance to change group midway through the quarter, but no one asked to do so. This held true despite the fact that members of three less functional groups were contacted individually and in private.

Identical groups were used in labs, recitations and lectures. To enhance cohesiveness, group pictures were placed on the web. Groups sat together during lectures to take group quizzes, and used a voting machine (VM) developed by the OSU PERG to answer conceptual questions. The VM is a wireless keypad system with more extended features than the Personal Resource System (PRS) [4]. Midterm scores were based 88% on individual and 12% on group work.

Groups also completed an "outside of class" project in which they designed a system to recycle unwanted droplets in continuous inkjet printers.

Results from end-of-quarter surveys:

Summaries presented in Table 1 were taken from end-of-quarter surveys completed outside of class. A small number of points were given for filling it out, and 45 of 62 students responded. For the multiple-choice sections, students were asked to respond to questions from -2 if they strongly disagreed to +2 if they strongly agreed.

When asked what was best about their groups, more than half of responding students concentrated on helping and communicating: "We help each other out; we never leave anyone behind." Others mentioned project-oriented concerns such as "groups help in planning" and

in "getting things done." When asked what was least beneficial, comments varied but frequently mentioned difficulty of getting together and not meeting enough. Few students had anything negative to say about group work.

Question	-2	-1	0	1	2	Mean
1	2	1	9	20	13	0.96
2	2	1	3	5	34	1.59
3	2	8	11	15	9	0.45
4	5	3	4	15	18	0.84
5	1	5	2	22	15	1.00

Table 1 summarizes 45 student responses to selected end-of-quarter survey questions:
Selected Group Work Questions:
(1) Having the same group in lecture, recitation and lab has helped me better learn physics.
(2) Having the same group in lecture, recitation and lab has helped my group become a better team.
Selected Voting Machine Questions:
(3) It bothers me when technical problems cause us to waste time.
(4) I like using the voting machine.
(5) Working in groups on the voting machine helps me.

Students enjoyed working in groups and believed that groups helped in learning physics. They strongly believed that using the same groups in all parts of the course benefited team development. It has been shown by others that working in properly structured groups can enhance learning [2]. One of the goals of this study was to determine whether emphasis on groups in all sectors of the course enhanced group cohesiveness. Students felt that it did.

Students also made positive comments about the VM system such as; "The Voting Machine allows groups to communicate and teach each other." However, they were bothered by technical difficulties and wasted time.

An upgraded VM system has been used by individual students with even more positive results in the winter 2004 electricity and magnetism quarter of the same course. Results will be presented in a subsequent paper.

Feelings in the 2003 course were strong on two other issues.

Students favored having a series of simple questions that guide them to some major concept rather than relying on a single complex question that does the same thing. Integrated over the class, students felt that the percentage of each type should be 61% to 39%. Extensive research already exists on this topic [5].

Also, even if every group correctly answers a question one should not assume that all members understand the concept. Each question was answered with one of 3 possible confidence levels. At the start of the quarter, questions that all groups answered correctly and with high confidence were not discussed. Unfortunately, many students hadn't understood and had deferred to group experts. After several complaints in a mid-course survey, every question was at least briefly discussed.

Group Project:

Midway through the quarter, students were assigned a group project: "Design the deflection method for a continuous-flow Ink Jet Printer." Continuous flow printers as shown in Figure 1 are used to cover large areas, such as for a billboard. Desired drops move in a straight line downward onto the paper, while unwanted drops are deflected into a recirculation gutter.

One commercial technique uses a charging cylinder employed during drop formation. If the cylinder is switched positive, negative image charges form on the drops and are retained as they separate from the nozzle. Drops can then be deflected into a gutter using oppositely-charged parallel plates.

Students were told that they not only had to develop a technique, but that their report had to sell management if they wanted their project to survive. This is a classic real-world situation not always addressed in the classroom.

Groups also had to decide how far to deflect drops, and whether they could achieve that deflection in 5 millimeters of vertical travel.

Piezo-electric constrictor applies pressure to the reservoir, causing ink to shoot out.

Ink reservoir

Ink stream

Formation of ink drops

Your system goes here. Unwanted drops must be deflected into a gutter in the 5 mm of vertical travel.
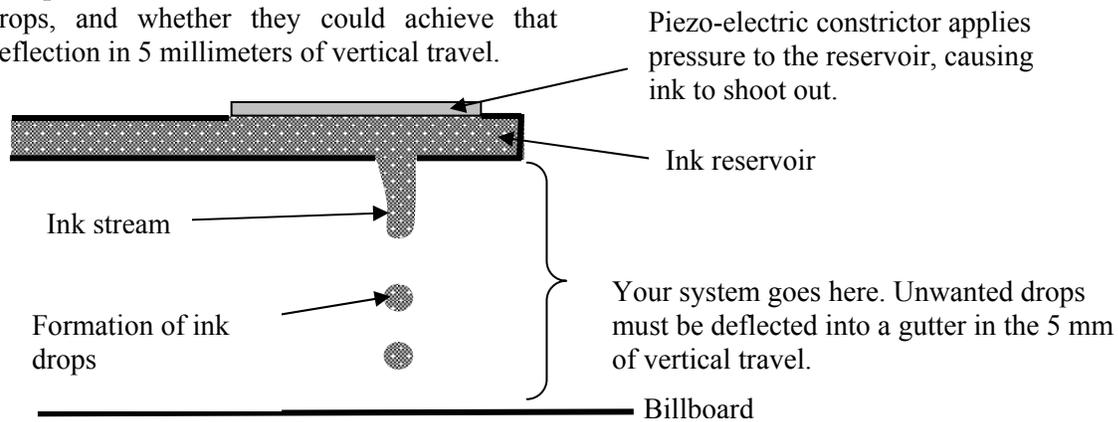
Billboard

Figure 1. This sketch was taken from the inkjet project description given to the students.

A week after the project was assigned, the instructor (nwr) conducted hour-long interviews with each of 17 groups. A prior discussion of the project during lecture had emphasized common features of business style groups such as creating an organizational structure with a leader, holding regular meetings, dividing work and creating a time line with benchmarks.

The first 15 minutes of each interview were devoted to a survey containing questions designed both to guide groups in forming a "business style" team and to ascertain whether they already had done so. Students were then asked to discuss the project with each other, and the instructor participated only if the group seemed to be floundering. During the final 15 minutes, the students were left alone to perform group activities such as selecting a leader, establishing a time and place for the next meeting and distributing work for people to bring to that meeting .

During the survey, groups were asked whether they had met as a group in person and/or by email to discuss the project, chosen a project leader, divided work and/or established a time schedule. They were queried as to whether individuals in the group had searched the web, read the book for inkjet material, or thought about the project in any way. They also were asked if they had met outside of class as a group for any reason prior to the interview.

All but a few students had thought about the project as individuals, and almost half had searched the web. However, none of the 62 students had looked at the textbook [6], which contained a brief discussion of inkjet deflection.

Seven of 17 groups had discussed the project for a few minutes before and after classes. However, prior to the interviews only one group had met outside of class for the project or any other reason, class-related or otherwise.

That group also was the only one out of seventeen that had selected a project leader prior to the interview. Most students thought of a leader as someone that gives orders rather than a facilitator who keeps projects on track.

Only two groups had devised any sort of time schedule, and only four had made an attempt to divide work.

Almost all of the students had participated in team sports, clubs or other activities that used skills useful for business-style groups. However, students had not connected these skills to the classroom. Most seemed to feel that working in groups was a *"classroom contrivance"*, as contrasted to something useful for their careers.

After their interviews, students became energized. By the end of the project, all groups had met outside of class 3 or more times. Thirteen of the groups had chosen leaders,

including all of those that submitted the six highest-graded reports.

The project also expanded student participation. Abstract thinkers concentrated on the charging process. Others felt comfortable making a realistic drawing of the system and estimating how far a drop had to be deflected. Some enjoyed writing the report or adding graphics and other eye-catching material.

However, groups also experienced difficulties. Some groups didn't cross-check their solutions and were penalized for designs that violated maximum design parameters.

All 17 groups divided the work load, but a few were penalized when one or more members failed to deliver. Only two groups set up any protection against non-delivery by group members, though during interviews this had been emphasized as an essential strategy.

Conclusions:

Becoming comfortable working in business-style groups is a long process. Still, the requirement to do so is a fact of life for most engineers. It seems reasonable to occasionally broaden group work from a learning activity into an one more strongly coupled to modern day demands.

This first attempt to establish "business-style" group work had negative and positive aspects. Using the same groups in labs, recitations and lectures, though favored by students, developed few of the skills required for business style groups. The fact that prior to interviews, only one group had met outside of class to study also may reflect on development of group learning skills. Forming groups is not enough; explicit group work training is required. This has been pointed out by several of the referenced authors.

Using groups to answer voting machine questions during lectures also could not be deemed a success. Several students deferred to others in their group without developing understanding, then complained vociferously in a mid-course survey. Individual voting as used

in a subsequent quarter appears more successful, and will be discussed in a forthcoming paper.

The "outside of class" project appeared to enhance business-style group skills. However, the reasons for this are less clear. Interviews may have been a tutorial for required skills. Alternatively, students may already have had many of the skills, but had not yet connected them to academic and professional situations. More study is required.

This further study also should become more quantitative. Business-style group skills that can be developed in a short-term project must be identified. Finally, techniques should be adapted or developed for measuring relevant proficiency levels.

References:

1. The ABET homepage is www.abet.org. Accreditation criteria can be traced from there.
2. P. Heller, R. Keith and S. Anderson, *Am. J. Phys.*, v. 60, 627-636 (1992). P. Heller and M. Hollabaugh, *Am. J. Phys.,* v. 60, 637-644 (1992). A useful URL is groups.physics.umn.edu/physed. Another source is D. Johnson and R. Johnson, "Cooperation and Competition: Theory and Research", Interaction Press (1989).
3. Group problem solving is one of several skills required in "business-style" groups. Another useful skill is addressed in D. Johnson and R. Johnson, "Learning to Lead Teams: Developing Leadership Skills", Interaction Press (1997).
4. A discussion of the PRS can be traced from the EduCue distributor homepage at www.educue.com .
5. R. E. Mayer, W. Bove, A. Bryman, R. Mars and L. Tapangco, *Journal of Educational Psychology* v. 88, 64 (1996). This article shows the advantage of using a series of simple pictures as opposed to a long verbal explanation such as required for a complex question.
6. Halliday, Resnick and Walker, *Fundamentals of Physics, 6th Edition.*