Small Group Learning in "Process Instrumentation Laboratory

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Abstract

Researchers report that, regardless of the subject matter, students working in small groups tend to learn more of what is taught and retain it longer than when the same content is presented in other instructional formats. Cooperative learning concept was applied to "Process Instrumentation Laboratory" (ChE315L), the first laboratory course for junior class students in Chemical Engineering Department. This course was overhauled and redesigned in order to promote participation of every student, teamwork spirit, and collaboration between students. This paper discusses the key steps of cooperative learning/teaching method and presents the outcomes of this course. Future work plans to improve this and other courses in chemical engineering will also be discussed.

What is Cooperative Learning?

Cooperative learning is the instructional use of small groups so that students work together to maximize their own and each other's learning. Considerable research demonstrates that cooperative learning produces higher achievement, more positive relationships among students, and healthier psychological adjustment than do competitive or individualistic experiences.[1,2] According to Johnson [2], the following five essential components must be present for small-group learning to be truly cooperative.

- A group must have clear positive interdependence;
- Members must promote each other's learning and success face to face;
- Hold each other personally and individually accountable to do his or her fair share of the work;
- Use appropriately the interpersonal and small-group skills needed for cooperative efforts to be successful;
- Process as a group how effectively members are working together.

Course Objectives for ChE315L

Course Description:

Experiments with written reports in measurement of mass, pressure, temperature, and volume; enthalpy of reactions; mass and heat balances; principles of process instrumentation and control equipment as they are applied to laboratory operation. Study of measurement error, statistical estimation and analysis.

Course Objectives:

The goal of this course is to introduce students to some practical skills they need to be able to apply the scientific and engineering concepts they have acquired in previous coursework. By the time students finish the course they should be able to achieve the following course outcomes:

- Organize and carry out experimental design and actual hands-on experiments;
- Understand safety regulations and safe operation procedures in Chemical Engineering laboratory;
- Be able to analyze and interpret experimental data with theories learned in previous courses;
- Write organized and cohesive technical memos and reports;
- Organize and prepare standard operating procedures;
- Work effectively in a team environment;
- Prepare and present technical works before colleagues and answer questions.

Deficiencies of Existing Learning/Teaching Approach

"Process Instrumentation Laboratory" (ChE315L) is a 2-credit-hour laboratory course for junior class students in Chemical Engineering Department. It is the first chemical engineering lab course in which students will be exposed to basic instrumentations and processes in chemical engineering, it also provides the students the first lesson on OSHA hygiene and chemical safety program, and more importantly the technical communication skills for report and memo writing and technical presentations.

In the past this course has the reputation of less important and boring due to lack of participation and interactions of some students. The typical size of this class was between 15 to 20 students. They had the opportunity to perform 4-9 experiments depending on instructor's experience and availability of department equipment funds. Most often the whole class performed the same experiment at same time, only a few active student had the opportunity to actually operate the instruments; many had to observe or didn't participate at all. The whole class shared and analyzed the same sets of experimental data, the discussed the same experiment. Only few quality reports were generated and most students were very dissatisfied with the outcome of this course. It was very difficult to fulfill the course objectives.

Course Overhaul and Redesign

This course was overhauled and redesigned in order to promote participation of every student and team work, collaboration between students. The feedback for this course from students and faculties are quite positive. The laboratory was completely renovated following OSHA laboratory safety regulations and NMSU laboratory safety and hygiene guidelines. Six representative chemical engineering process experimental projects were selected. Before lab sessions, four lectures were given on laboratory safety, fundamentals of process instrumentation, principals and goals of each project, experimental data acquisition and processing, technical report writing and project presentation.

The whole class was then divided into five groups. Each group consisting of three students was assigned different projects at each rotation period. The group members took turns to lead different projects and made the final project presentations. Each group worked on different projects at same time; every student was involved and had a chance to operate all the instruments. The whole group had to cooperate well in order to finish the project. Although the group members could share the experimental results and procedures; each student had to analyze the data independently, and to submit an individual report. Several key steps involve in the cooperative learning are discussed as follows.

Forming and Guiding Groups

Most professors who have included cooperative in their courses agree that groups of between 4 and 6 students seem to work best, though depending on the task, larger groups (8-10 students) can function successfully. Determining how the groups will be formed can be more complicated, since ideally the groups should be diverse enough to include students with a range of intellectual abilities, academic interests, and cognitive styles. It is believed that allowing students to select their own group members can work well in small classes. Since the class size for this year's ChE315L was only 15 students, so I divided the class into 5 groups, asked students to volunteer as team leader for the first project and let them to pick their team members. It turned out this worked perfectly for this course. The end of semester evaluation of team members and group effort from this class was overwhelmingly satisfactory. All students gave almost 100% grade to their team members' effort.

Once groups have been determined, the assignments for each group were decided and rotated. Each group performed a different experimental project during each rotation period. It is quite challenging and time consuming for professor to instruct different groups at same time, especially for the first time of each project. I gave four lectures to the whole class before they were divided into small groups. The basic principles and some technical details or difficulties of each project were covered. During group instruction, I spent about 30 minutes to explain the project to the small group in the laboratory. Sometimes I needed to show the group how to operate the instruments. The small group instruction was very effective for experimental projects because I could receive the feedback from each student right away, and provided individual instructions for different students. We discussed project plan with the group during this meeting, most often the group leader led the effort for the project and made tried very hard to involve every member. I also met with each group during the course of each project to ensure smooth progress. In offering feedback during group projects, however, it's important to allow students to make their own decisions about how to proceed. The instructor's role is to guide but not dictate what should happen amongst the group members. If, for example, group members complain that someone isn't doing his or her fair share, make it clear that solving this issue is up to the group and won't be solved by the intervention of the instructor.

Teaching Students to Work Effectively in Groups to Promote Teamwork Spirit

In a competitive academic environment, where students have most often been rewarded for individual effort, collaboration may not come naturally or easily for everyone. And even though most students have worked together informally in study groups or social organizations, they may never have thought carefully about the kinds of skills that best promote group achievement. When the group assignments were handed over the students, I made it very clear that it is the responsibility of each project leader to plan and execute the projects. However each group member has to actively participate and contribute to the group project goals. Group members can share and discuss the experimental plans, procedures, collecting and analyzing the experimental data, but each group member has to submit individual report representing his or her own efforts. Each student could draw different conclusions from same sets of data and made different recommendations.

The interpersonal and organizational skills needed for managing a group project were highlighted in each assignment, so that students recognized the importance of such things as: listening, clarifying statements, and providing good feedback; keeping discussions on task; probing assumptions and evidence; eliciting viewpoints and perspectives; mediating conflicts; and summarizing and presenting findings.[3] All experimental projects need close collaborations between three group members in almost every phase of the project. Some experiments couldn't be successfully done without collaborative team effort. This gave a very good training for the team leader and all team members for their leadership and teamwork.

Peer Teaching to Build Students' Confidence

The uniqueness of this course was the peer teaching and interactive learning from each group's project presentation. Project leader of each group led the team effort during the project, and made the final project presentation after each rotation period. Each group member had to contribute to the presentation, and Q&A. Since all groups did different projects during a rotation period, every student had a chance to learn from the presentation about their future projects, the presentation skills, or compared the results of the same project his or her group performed previously. Group presentation greatly stimulated teamwork spirit and united the team members. It also spurred a healthy competition between groups for getting better results.

The feedback from group presentations was quite positive, especially for students without presentation experience. This course gave all students a chance to practice and polish their presentation skills. Making presentation right after each rotation not only allowed students to discuss the projects with enthusiasm, but also greatly alleviated the time pressure during the semester final weeks. More importantly it gave very timely and good feedback about the cooperative learning approach and students' performance. Several adjustments/modifications were made for many projects according to the presentation and students' Q&A.

Evaluating Group Work and Grading

Individual accountability was essential in ensuring successful group work, both individual and group effort must be taken into consideration in the final grade. Although individual accomplishment in the group work itself can be assessed from the project reports and final quiz, team effort should also be weighted so that members feel that even their contribution to the group has been evaluated adequately.

It was quite challenging to assess the performance of each student within a group because they shared the experimental results and contributed collectively to the presentation. The students learned and benefited from the project presentation of other groups; this was taken into consideration in grading the project reports and evaluating group performance. Teamwork and safety were also weighted in the final grade to promote teamwork spirit and safe working habit. The feedbacks from students, faculty members and Chemical Engineering Academy about this teaching approach were quite positive.

The weight of the project reports in final grade was about 50%, which is large enough to assess individual efforts and performance. The group performance that had significantly impact on the quality of the reports accounted for about 40%. Another 10% was allocated for peer evaluation of each group member's participation, group contribution, teamwork and safety. Students can't be successful without good group performance. However, a good group performance is not sufficient to carry each member without significant individual effort.

Future Projects

A new project will be added next year to allow students to take charge of the whole process of designing experiment, purchasing the instruments and chemicals, installing the apparatus, performing the experiment and presenting the results. This is very close to a real world research project and is going to be more challenging and interesting. It requires all group members to work very closely and collaboratively in order to make it a successful project. The same cooperative learning concept will also experimented in other core courses in chemical engineering I will be teaching. The object is to allow students to have an interactive learning environment.

References

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