Enhancing Engineering Students' Communication Skills through a Team-Based Graphics Course Project

Leroy L. Long III
Embry-Riddle Aeronautical University, longl2@erau.edu

Kari Jordan
Embry-Riddle Aeronautical University, jordaka16@erau.edu

Enhancing Engineering Students' Communication Skills through a Team-Based Graphics Course Project

L. L. Long III and K. L. Jordan
Department of Engineering Fundamentals
Embry-Riddle Aeronautical University, Daytona Beach, FL

Abstract

Although communication skills are highly valued by engineering associations and companies, instructors may find it difficult to incorporate them into specific engineering courses. Some attention has been given to research on undergraduate students' communication skills. However, additional research and training is needed to help instructors develop curricula – the type that can enhance students' communication skills – in technical subjects like engineering graphics. Such work can help engineering programs offer increased opportunities for students to continually develop desirable professional traits throughout their collegiate experience. This paper will explore the implementation of a team-based graphics course project – one that focused on enhancing engineering students' communication skills – and provide recommendations for faculty teaching similar courses. Findings from open-ended survey questions indicate that students learned the importance of preparation, time management, organization, clarity, detail, and engagement. By working in a project team, students also learned patience and task delegation.

Introduction

Communication skills are important for success in various corporate and community roles, especially leadership. Teamwork, creativity, and problem-solving abilities are also essential in industrial settings. Since a present-day goal of engineering education is to prepare students for their desired career, educators should continually strive to develop the aforementioned competencies through their courses and curriculum. Effective communication is critical in fields that require individuals to collaborate across cultures and disciplines, and produce products for everyday consumer use.

Numerous national organizations have highlighted the significance of specific skills and abilities within the engineering profession. In *The Engineer of 2020: Visions of Engineering in the New Century*, the National Academy of Engineering (NAE) provided a comprehensive list of strategies to improve engineering education and better prepare future engineers (NAE, 2004). The list included (a) good communication and teamwork skills, (b) practical ingenuity to solve problems, and (c) creativity. While identifying several desired learning outcomes for engineering undergraduates, the Accreditation Board for Engineering and Technology (ABET) also stressed the

importance of (a) communicating effectively, (b) working on multidisciplinary teams, and (c) designing and solving realistic problems (ABET, 2015). Scholars have also examined the importance of teamwork and collaboration in science, technology, engineering and mathematics (STEM) fields (Long, Williams & Strayhorn, 2013; Springer, Stanne & Donovan, 1999; Stump, Hilpert, Husman, Chung, & Kim, 2011; Terenzini, Cabrera, Colbeck, Parente & Bjorklund, 2001). In fact, the Engineering Communication and Performance minor, developed at the University of Tennessee, has embraced the notion that "working with other people is a learned skill" (Seat, Parsons, & Poppen, 2001).

Although academics and national organizations (e.g., ABET, NAE) offer recommendations for improving STEM education, instructors may find it difficult to integrate them into particular undergraduate engineering courses. Building upon previous research on undergraduate students' communication and teamwork skills, this paper focuses on these abilities in a specific technical subject like engineering graphics. This paper offers additional knowledge concerning ways to help students develop desirable professional traits throughout their undergraduate engineering experience.

Course Description

An introductory graphical communications course at one small, private Southeastern school is designed to familiarize students with basic principles of drafting and engineering drawing as well as to improve students' three-dimensional (3-D) visualization skills and ability to use a computer-aided design (CAD) program. A variety of topics are covered such as orthographic projection, section and auxiliary views, assemblies, dimensioning, and tolerances. When completing a team-based, semester-long design project, students focus on three forms of communication (i.e., visual, written and oral). The following course objectives were created around the aforementioned types of communication skills (Figure 1):

Students will be able to,

- Use CATIA as a computer-aided drafting tool to produce multiview, isometric, auxiliary, and section views (i.e., through visual drawings)
- Describe how their team modeled the components of a product explicitly in a detailed assembly (i.e., in written form)
- Discuss the steps taken to achieve their final drawing package and convince panelists to buy their product (i.e., through an oral presentation)

Figure 1. Graphical communications learning objectives (communication skills)

To meet the requirements of the course project, students are provided the following specifications (Figure 2):

Final Project Specifications

Due Date:	Last day of class
Final Grade Contribution:	20%
Purpose:	The purpose of this project is to model the components of a product explicitly in a detailed assembly. Each part and assembly must have a detailed drawing.
Deliverables:	Each team will submit one (1) printed drawing package and binder to include *at least* the following. 1. Cover page 2. Statement of Work 3. Detailed Sketch 4. Assembly Drawings 5. Detail drawing for each part in the assembly Additionally each team will give a 15 minute "Shark Tank" presentation discussing the steps taken to achieve their final drawing package. The ultimate goal is to convince panelists to buy your product.
Grade Calculation:	20% **Individual Parts** - Well Modeled - Appropriate Views - Appropriate Dimensions - Necessary Notes - Title Block 20% **Assembly Drawing** - Compact View - Exploded View - Parts List - Balloons - Title Block 20% **Presentation** - Attire - Clear Problem Statement - Detailed Project Timeline - Creativity 20% **Project Binder** - See Template 20% **Peer Evaluation**

Figure 2. Graphical communications final project specifications

The primary purpose of the course project is to have students model the components of a product explicitly in a detailed assembly. Students must also effectively communicate their designs and thought process during each design phase of the project. Students are free to choose a product of interest to their team. Each part and assembly of the product must have a detailed drawing. Each team uses hand/drafting techniques and a software program called Computer-Aided Three-Dimensional Interactive Application (CATIA) to create their drawings. For extra-credit, students

are also encouraged to improve a current product, meet a grand challenge of the 21st century (NAE, 2008), provide a quote to have their product 3-D printed, and/or create a poster for participation in a course-wide competition.

In the engineering graphics course, eighty percent (80%) of the final project score deals with visual (40%), written (20%) or oral communication (20%). Students are to develop a "Shark Tank" presentation – based on the television show – whereby they present their design orally to a panel of instructional staff members who are interested in buying their product. Each team also submits a binder to their instructor that contains an executive summary, needs assessment, background research, alternative solutions, and engineering drawings.

Lastly, twenty percent (20%) of the final project grade comes from peer evaluations. Individual members provide feedback on team dynamics such as (a) how effectively the team worked together, (b) whether there were behaviors of any member that were valuable or detrimental, and (c) what they learned from working in a project team, specifically in terms of communication, that they will carry into their future experiences.

Course Feedback

Open-ended responses from the Fall 2015 semester provide insight into students' perceptions of the course project. Students learned several transferrable skills as it relates to visual, written, and oral communication, as evidenced by the following survey excerpts. When focusing on visual communication, students stated:

> "I learned to always make sure that if I was handed my drawing and told to manufacture the part or assembly that I would have all of the dimensions and information otherwise to accomplish the task."

> "Keep the work neat, clear, and marked with proper notations. The drawings need to be descriptive and concise, especially with the dimensioning, in order to convey the information more effectively."

In terms of written communication skills, numerous students revealed:

> "Start early and revise often for the best results."

> "It is very important to have a very structured and organized [written] report."

> "Be thorough, but concise with the language used in any [written] report."

For oral communication, several students highlighted:

> "Preparation is key to a good oral presentation."
>
> "It is important to make eye contact and to really know your project or topic because the more you know, the more confidence you have which really affects the way you present."
>
> "Speak up, speak slowly, and take your time to go in-depth about important topics."
>
> "Enthusiasm for the subject is important for a well-received presentation."

Overall, when seeking to communicate effectively, students noted the importance of preparation, time management, organization, clarity, detail, and engagement.

Students in the graphical communications course also spoke of positive experiences while working in a team:

> "I learned to trust my teammates."
>
> "I learned that communication is everything in a group environment"
>
> "I learned that patience and respect are some of the most crucial elements of a team member. It is imperative for a team member to listen to others' ideas and respect their thoughts, opinions, and feedback."
>
> I learned that each person has a unique skill set. If you take the time to thoroughly get to know each member of the team, and understand their strengths and weaknesses, it will save time in the long run when delegation of tasks is necessary.

Findings from prior research support the above quotes. For example, facilitating teamwork among fundamental engineering courses promotes peer teaching and collaborative learning. These strategies provide students with an "authentic learning context" and enhance the student's sense of ownership (Missingham and Matthews, 2014).

Despite these positive reflections not all students feel that team projects are beneficial. When reflecting on their experiences, students said the following:

> Group projects at this early of a stage in our college career do not fair too well. Many students are fairly new to the college experiences and most would do work the day of or the day before it is due.

> [Through the team project, I learned to] make sure that all of the team members contribute to the project and alert the professor earlier to any problems with one of the group members.

These quotes are consistent with previous research results. For engineering students, difficulties in team projects arise from students' inexperience working in teams (McGuire, Li & Gebali, 2015). Considering the above feedback from students along with the goals of engineering organizations and faculty, conclusions and recommendations are offered in the next section.

Conclusion & Recommendations

Incorporating visual, written, and oral communication in a graphical communications course has produced positive feedback from student evaluations. Students saw the benefit of communication when completing a team-based, semester-long design project. Students noted the importance of preparation, time management, organization, clarity, detail, and engagement. However, problems sometimes occurred with respect to communication among team members. Student concerns included non-responsive teammates and procrastination.

To address these concerns, instructors should convey clear objectives at the beginning of the semester in terms of what students are expected to learn with respect to visual, written, and oral communication. Instructors should consider having students create team working agreements to establish a primary means of communication, schedule for meetings, general responsibilities for all team members, and methods for resolving conflict. Instructors can also have students submit team participation agreements for each assignment to document how each member equally contributed to the task. Instructors should assign project deliverables throughout the semester so students can periodically work towards deadlines and receive feedback. Additionally, assigning roles for each team (e.g., leader, organizer, negotiator, and graphic designer) can allow tasks to be properly delegated and issues to be rectified in a timely fashion.

References

Accreditation Board for Engineering and Technology (ABET). (2015). Criteria for Accrediting Engineering Programs, 2015-2016. Baltimore, MD: ABET. Retrieved from http://www.abet.org/accreditation/

Long, L. L., III, Williams, M. S., & Strayhorn, T. L. (2013). How relationships with faculty and peers affect value development in undergraduate engineering education: A national survey analysis. Proceedings from *2013 ASEE North Central Section Conference.* Columbus, OH.

McGuire, M., Li, K. F., & Gebali, F. (2015). Teaching design to first-year engineering students. Proceedings from *2015 Canadian Engineering Education Association*. Chicago, IL.

Missingham, D., & Matthews, R. (2014). A democratic and student-centred approach to facilitating teamwork learning among first-year engineering students: a learning and teaching case study. *European Journal of Engineering Education, 39*(4), 412-423.

National Academy of Engineering (NAE). (2004). The Engineer of 2020: Visions of Engineering in the New Century. Washington, D.C.: The National Academies. Retrieved from http://books.nap.edu/catalog/10999.html

National Academy of Engineering (NAE). (2008). The Grand Challenges for Engineering. Washington, D.C.: The National Academies. Retrieved from http://www.engineeringchallenges.org/challenges.aspx

Seat, E., Parsons, J. R., & Poppen, W. A. (2001). Enabling engineering performance skills: A program to teach communication, leadership, and teamwork*. *Journal of Engineering Education*, *90*(1), 7-12.

Springer, L. Stanne, M. E. & Donovan, S. (1999). Effects of small-group learning on undergraduates in science, mathematics, engineering, and technology: A meta-analysis. *Review of Educational Research, 69*(1), 21–51.

Stump, G., Hilpert, J., Husman, J., Chung, W., & Kim, W. (2011). Collaborative learning in engineering students: Gender and achievement. *Journal of Engineering Education, 100*(3), pp. 475-497.

Terenzini, P., Cabrera, A., Colbeck, C., Parente, J., & Bjorklund, S. (2001). Collaborative learning vs. lecture/discussion: Students' reported learning gains. *Journal of Engineering Education, 90*, 123-130.