Technician-Technologist Teamwork: Multifunctional Collaboration on Industry Projects

Dr. Nancy K. Sundheim, Saint Cloud State University

Nancy K. Sundheim developed and is now the director of the Manufacturing Engineering Technology program. Her primary interest area is at the intersection of manufacturing engineering and statistics involving lean, continuous improvement, and quality. She also does research in engineering education applying the principles of continuous improvement to her teaching.

Aaron J. Barker, St. Cloud Technical and Community College

Colleagues know Aaron as a dedicated and enthusiastic individual with a passion for teaching and the ability to think outside the box. When Aaron became the head of the electronics program at St. Cloud Technical & Community College in 2009, the program's existence was being threatened by very low enrollment. Since then, he has been the driving force for the success of the program and has played a major role in the development of other new programs at SCTCC.

Aaron was instrumental in helping SCTCC partner with Xcel Energy in 2010 to develop the Nuclear Technician Program. The program is designed to prepare graduates for work as Nuclear Plant Maintenance Technicians. The nuclear track is the newest addition to SCTCC's current catalog of energy tracks: wind power, ethanol, bio-diesel, solar power, and fossil fuel energy production.

In addition to his roles as a college instructor, Aaron is also actively involved in volunteering his time to students outside of SCTCC. One example of his commitment to serving students and the community has been his role as the event organizer for the region's VEX Robotics competition. The program uses robotics as a way to introduce middle and high school students to science, technology, engineering, and math in a fun and collaborative environment. St. Cloud Technical & Community College hosted Minnesota's first VEX Robotics World Qualifying competition in 2012 and the event has grown ever since.

Technician-Technology Teamwork: Multifunctional Collaboration on Industry Projects

Abstract

The importance of multifunctional teamwork has been advocated for some time. This includes having technicians and engineering technologists learn to work effectively together. The goal of this pilot project was to have students from 2-Year and 4-Year programs learn to value their counterparts by working together on a combined two-week class project. Teams of two technicians and two technologists were created and assigned a real project from industry. Five companies provided the 8 projects. Project performance was measured with a common rubric. All teams exceeded the high expectations of both instructors and there was no appreciable difference in performance between the two groups of students. The companies found the experience valuable and were already implementing student solutions by the end of the two-week project. Major challenges were the logistics of finding meeting times/locations and the short time span for the pilot project. Despite this, students were very positive about the experience and would like to do it again. Industry is also expressed interest in participating in a longer version of this collaboration. Plans are underway to continue with a semester-long version of the collaboration.

Introduction

The American Council on Education and the Education Commission of the States issued an influential national report in 1983 [1]. In this report, they challenged educational institutions to cooperate. The American Association for Higher Education responded by making collaboration a key focus of its national reform agenda. This has spurred a number of partnerships over the past 25 years. The focus has been on stronger connections between K-12 schools and post-secondary institutions, professional development opportunities for college faculty, and development of articulation agreements. Most collaborations between two- and four-year institutions have involved improving success of transfer students.

At the same time, there has also been an increasing awareness that industry needs graduates, from both two- and four-year programs, that can perform effectively on multi-functional teams. A 2016 review of the literature [2] concluded “STEM interdisciplinary opportunities need to be addressed at a post-secondary level.” The primary goal of this project was to provide an opportunity for students in two-year and four-year programs to work together.

A secondary goal was to tighten the relationship between the two institutions. The four-year university has a relatively new engineering technology program. There is a need for some

practical hands-on technical electives, but the university does not have the resources to provide these. The community college, a ten-minute drive away, has excellent programs in place and can provide these necessary electives. It does not make sense to duplicate resources. Meanwhile, some of the graduates of the two-year programs wish to continue their education, but are not very aware of the opportunities at the university. Enabling both sets of students to become comfortable with the other campus could be a win-win.

To address these goals, a two-year and a four-year school developed a pilot study involving a joint project for local companies. Each project was assigned to a mixed team comprised of students from both schools.

Background

Multifunctional teamwork has long been advocated by industry. Cuseo [3] notes that one of the seven major challenges issued by the 1983 American Council on Education report is for leaders across all levels of education to cooperate. Ralph [2] concluded from an extensive literature survey that interdisciplinary opportunities need to be addressed at the post-secondary level.

The Harvard Business Review [4] found that nearly 75% of cross-functional teams in industry are dysfunctional. The research indicated most such teams fail because the different disciplines don't work well with each other, i.e. engineers don't work well with designers, designers don't work well with marketing, etc. Randell [5] further noted that most attempts to create cross-functional teams don't address the factors that actually cause most of the dysfunction. Of the four factors noted, one is a lack of understanding concerning the functions of the other team members.

Thus, schools are now trying to address this during the educational phase. Some examples are:

- In Spain [6], students from different degree programs worked collaboratively on a project. The faculty developed a common rubric which was also made available to students. Although this only involved students from one four-year school, it did show success in helping develop multi-functional teamwork skills.

- In Finland [7], teams composed of one engineering student and one design student were placed as a team in internships. The two students worked jointly on a project for the company. This pairing resulted in teams that were more creative, effective, and autonomous than when the engineering students were placed alone in an internship.

- Another study [8] described a course that was offered to a highly selective group of students in a variety of disciplines including graphic design, digital media, computer science, public relations, journalism, and marketing. Students reported the experience

helped develop more professional attitudes toward meetings, deadlines, interpersonal communication, teamwork, and problem-solving skills.

The studies noted above were interdisciplinary, but involved only students from the same institution. This call to interdisciplinary work includes having technicians and engineering technologists work together, i.e. students from two- and four-year programs.

Two- and four-year schools have explored various connections. In Samuel, et. al. [9] the university gave the two-year students access to their equipment. This collaboration also had instructors jointly create a module to be used in both curriculums. However, the students only worked with other students in their program. The students did not work together across schools.

A California collaboration [10] revised several courses at both the community college and the university to incorporate a NASA theme. Again, students only worked with students from their same institution in these courses. However, these institutions also placed carefully selected two-year students in courses at the four-year school. They received 3 credits of independent study from the two-year school. All of these students were successful and received an A.

Cuseo [3] lists a large number of practices that have been developed. Among them are the following:

- Cross-registration agreements to expand the curriculum of both schools.
- The four-year institution offers completion at the two-year campus.
- Mentoring between four-year faculty and two-year students.
- Summer bridge courses taught jointly by two- and four-year faculty

Florida has been a leader in such ventures, creating true 2+2 programs with common course numberings. [11] Ventura County Community College and Moorpark College in Florida developed a series of courses held on both campuses, all centered around service learning [11]. Their experience has resulted in some valuable observations. They suggest the best way to make these partnerships successful is to make sure the effort is about the student and not about shoring up an institution or about fundraising.

Method

Project Set-up. There were fifteen 2-Year students and seventeen 4-Year students. Eight teams were formed with four members: two from the 2-Year school and two from the 4-Year school. In one instance the team included only one 2-Year student and three 4-Year students. The pilot project was run the last two weeks of the term. Both instructors rearranged their courses to cover all content by this time, so students were only required to work on the joint project these last two weeks.

Instructor Selection. Both instructors involved were very open to the idea and were excited at the possibilities it offered their students. Furthermore, when they first met to discuss a possible collaboration, it was quickly discovered that they had similar teaching approaches and were both always on the look-out for experiences that brought value to their students.

It should also be noted that both deans were 100 percent on board with the proposed collaboration.

Course Selection. The courses selected had similar enough student learning outcomes that the project could meet the needs of both. See Table 1 for course descriptions. Both courses cover some of the same content so the students had a common language. However, there are enough differences in the content that each set of students should have been able to bring some special expertise to the table. Thus, the students could learn from one another and come to value the insights that different perspectives can offer.

Table 1. Course Descriptions

	Two-Year	Four-Year
Course Title	Quality Practice	Continuous Improvement
Program Requirements	Required	Required
Course Description	This course is designed to align with the National Skills Standard assessment and certification system for Quality Practices. The course curriculum is based upon federally-endorsed national standards for production workers. Emphasis is placed on Continuous Improvement concepts and how they relate to a quality management system. Students will be introduced to a quality management system and its components. These include corrective actions, preventative actions, control of documents, control of quality records, internal auditing of processes, and control of non-conforming product.	Continuous improvement strategies. Six sigma basics, statistical quality control tools, benchmarking, lean principles, inspection strategies, total quality management, quality function deployment.

Project/Company Selection. A request was sent to the industry advisory boards of both programs. Five companies responded, providing eight projects total. The variety of projects allowed us to see how the collaboration would work under different settings. Furthermore, the final presentations gave all the students a nice variety of exposure to continuous process improvement tools applied to more than one situation. A brief description of the projects is given in Table 2.

Table 2. Continuous Improvement Projects

Company Type	Project(s)
Automation integrator	(1) Improve flow of receiving/staging area (2) Improve assembly process (3) Improve storage/retrieval of raw materials
Wood cabinetry	(1) Improve adherence to tolerances for one product (2) Reduce variation between two production processes
Granite and bronze products	(1) Improve flow of bronze marker assembly line
Precision semiconductor tools	(1) Improve panel assembly process
Steel processing	(1) Error-proof a material handling process

Description of Students. The university students were all in a Manufacturing Engineering Technology B.S. program except one who was in a Technology Management program. Half were 4th year students and the rest were 3rd year. Students from the community college were in a variety of A.A.S. and diploma programs including Robotics and Automation, Mechatronics, Instrumentation and Process Control, and Biomedical Equipment Technician. They were all 1st year students.

Combined Rubric. The two instructors created a common rubric for the project so both sets of students would have the same investment in the project. Table 3 shows a rough breakdown of the expectations in the rubric.

Table 3. Project Rubric Outline

Category	Percentage of Project
Identification of production issues	12.5
Selection of issue(s) to address	12.5
Analysis of the selected issue(s)	26.3
Suggested solution(s)	17.5
Communication (report, presentation)	18.7
Teamwork	12.5

Student Attitudes. After final project presentations, all students were given a survey to gather feedback on their experience. Questions gathered their initial reaction to participating in the joint venture and their perception of the value and effectiveness of the opportunity.

Industry Evaluation. The industry partners were also given a survey at the conclusion of the collaboration regarding the effectiveness of student solutions.

Results

Student Performance. Both instructors had high expectations for the students. Even so, every single team thoroughly exceeded those expectations. Only two students, both from the two-year

school, received less than 90%, primarily because they were too quiet during the final presentation. Nonetheless, their scores were both 89.3%. So essentially all students received an A on the project. Table 4 gives results for each set of students and for all students combined.

Table 4. Total Project Score, in percent

School	Sample Size	Mean Project Score	Standard Deviation
2-year	17	93.49	2.63
4-year	15	95.59	1.09
Difference	2	2.10	1.54
Combined	32	94.60	2.21

Using an alternative hypothesis of no difference (H_0: $\mu_2 - \mu_4 \neq 0$), the difference of 2.10% is statistically significant at the 5% level with a p-value of 0.010. However, it should be noted that although the instructors strove to be consistent, there was not good communication in the final scoring. The instructor from the two-year school used half and quarter points whereas the instructor of the four-year school did not. If she has done so the scores of the four-year students would have been a little lower.

Keeping that in mind, Table 5 gives results of differences between the schools, as well as the combined average, for each of the 6 components of the project rubric. The p-value is for the same alternative hypothesis as above. Figure 1 enhances this information by displaying the group averages graphically.

Table 5. Comparison of Schools on Each Project Component, in percent

Component	2-year mean	4-year mean	Difference	p-value	Combined Averages
Identify Issues	94.50	100.00	–5.50	0.0026 *	97.4
Selection Issue(s)	94.50	97.65	–3.15	0.0148 *	96.2
Analysis	93.65	93.28	0.37	0.8198	93.5
Solution(s)	95.36	99.16	–3.80	< 0.0001 *	97.4
Communication	85.67	89.80	–4.14	0.2340	87.9
Teamwork	96.33	97.65	–1.31	0.5338	94.9
Total Score	93.49	95.59	–2.10	0.0100 *	94.6

* Statistically significant difference at the 5% level of significance

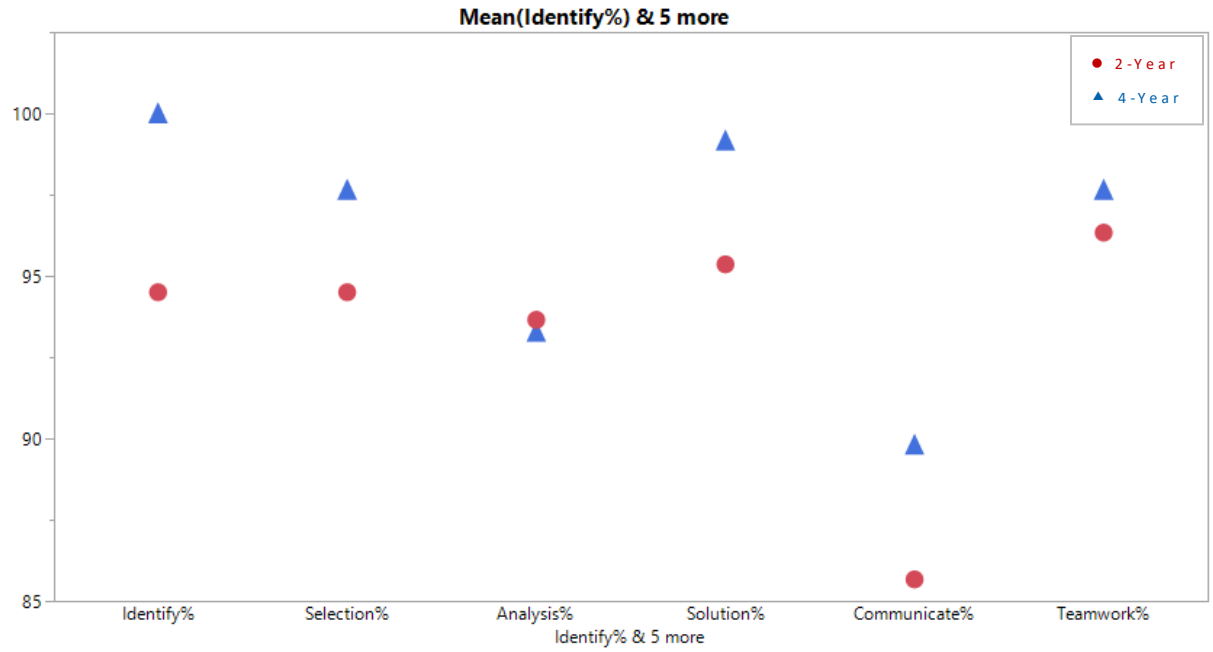

Figure 1. Mean Scores by School for Project Components

(In all cases, except Analysis, the 4-year school has a higher percentage.)

Student Feedback. Students were given a survey at the completion of the project to gather their feelings about the project. In all cases, n is 17 for the 4-Year school and 15 for the 2-Year school. When combined, n is 32.

The first question asked about attitude *before* the project. See Table 6. This allowed for 4 possible responses:

1 = Very excited

2 = Somewhat excited

3 = Neutral

4 = Unhappy about it

Table 6. Responses for the Pre-Project Attitude, 4-point Likert Scale

Question	4-Year	2-Year	Combined
1. Before the collaboration I was ...	1.88	1.77	1.83

Distribution of attitudes before the project are shown in Figure 2. This shows no students were unhappy, about 20% were neutral, and the bulk of students were excited.

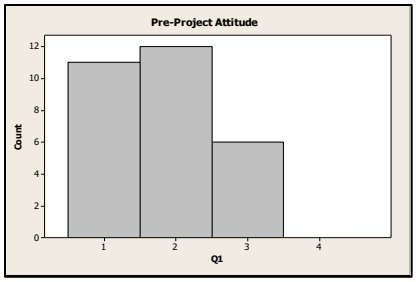

Figure 2. Distribution of Pre-Project Attitude, on the 4-point scale given above

Mean responses to 5 *post*-project questions are given in Table 7. The only significant difference was on question 3, and that was barely significant at the 5% level so the combined scores can be used to describe student feelings about the collaboration.

Table 7. Post-Project Responses, Likert scale from 1 (strongly agree) to 5 (strongly disagree)

Question	4-Year	2-Year	Combined
2. Partner from same school contributed a lot	1.44	2.17	1.75
3. Partners from other school contributed a lot *	2.13	1.46	1.83
4. Believe better final solution because of collaboration	1.75	1.38	1.59
5. A valuable experience preparing students for their future	1.81	1.31	1.59
6. Enjoyed the experience	1.69	1.62	1.66

* 2-Year is (barely) significantly lower, p-value = 0.0452

Distribution of attitudes after the project are shown in Figure 3. The distributions are more skewed than that shown in Figure 2 with somewhat stronger positive attitudes after the project. '1' is best so a lower number is better. In other words, student attitudes toward the project seemed to shift more positive after the experience.

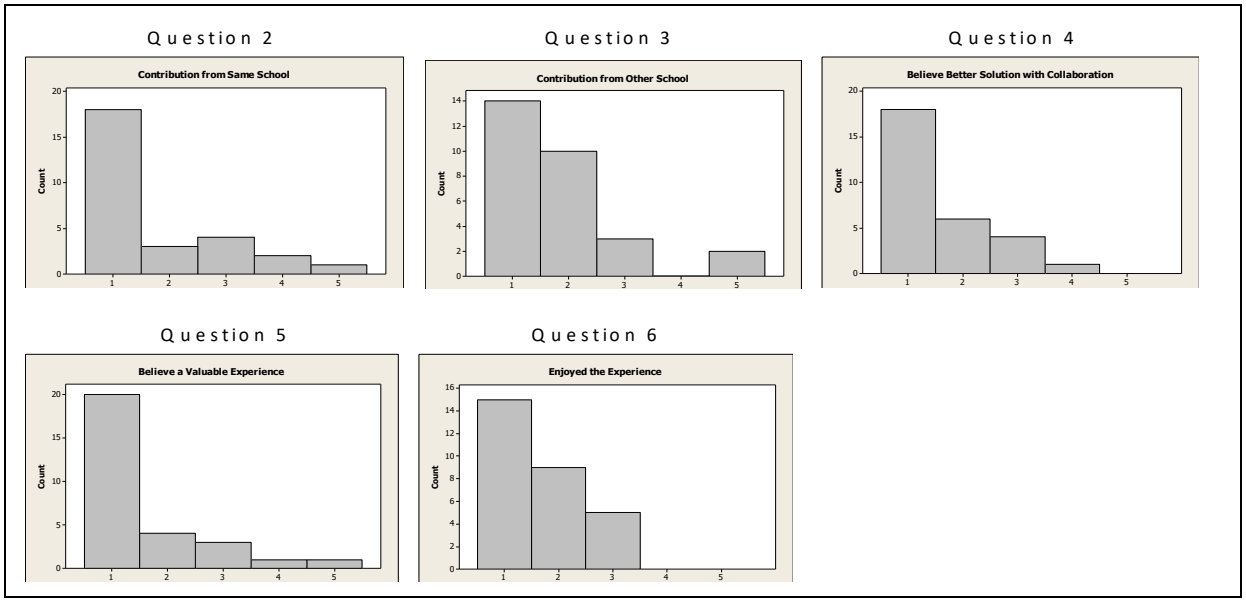

Figure 3. Distributions of Post-Project Attitudes, all on a 5-point Likert scale (1 = strongly agree)

Industry Feedback. Ten representatives of the five companies completed the survey. Table 8 gives results. A Likert scale was used with 1 = strongly agree and 5 = strongly disagree.

Table 8. Industry Responses, 1 is best, 5 is worst, n = 10

Question	Average Response
Believe collaboration between technician and engineering technologists is very valuable	1.3
Enjoyed working with the students	1.4
Accounting for the short time frame, our company gained value from the project(s)	1.6
If timing is right, we would participate in an expanded version of this project	1.3
It would be good to see more collaborations between technician and technology students	1.5

At the time of the final presentations, three of the five companies made a point of telling the instructors they had already implemented or were in the process of implementing suggestions from the students.

Only one found little value in the final recommended solution(s) and one was neutral on both the value received and whether they would participate again. It should be noted that all but one company had more than 1 representative so it is most likely that this view was not shared by a company but only one individual. All other participants were highly positive and very ready to continue working with such student projects.

Discussion

Student Performance. All groups performed very well. Every group exceeded the high expectations of both instructors. The 2-Year students, on average, performed less well than the 4-Year students on identifying issues, selecting the issue(s) to address, and in generating solutions. However, as mentioned above, this is more likely a difference in instructor grading. A conclusion that 4-Year students performed better is not really appropriate at this point. It should also be remembered that the 2-Year students were all in their 1st year whereas the 4-Year students were all in their 3rd or 4th year.

Overall the students did quite well on all components of the project except communication. In general, the students did well with the presentation but written reports were somewhat lacking.

Student Feedback. Although the 2-Year students seemed a little more hesitate about the collaboration before the project, this difference was not statistically significant. On average, all students were excited about the opportunity to work with students from another school. Both instructors were very excited about the collaboration and it may be that this excitement influenced student outlook right from the beginning. Instructor enthusiasm is likely a strong factor affecting student attitudes.

Students as a whole believed both the other student from their school and the students from the other school contributed a lot to the project. This hopefully showed students that job function does not have to be an issue in the workplace. Informal student feedback throughout the two weeks was nearly all extremely positive. Most indicated they were enjoying working with "the other students."

This is not to say there were no issues! At the beginning of the project some of the engineering technology students complained that the 2-Year students were not returning emails. The 4-Year instructor explained that these are 1st year students and have really not yet been trained in group work. The older students needed to be the model. It was pointed out that they also have some classmates they don't like to work with for the same reason. So, this is not necessarily a *job function* issue, but a *personality* issue. In the end all these communication issues went away (for the most part). The value here was the opportunity to point out the uselessness of stereotypes regarding job function.

In one instance a 4-Year student was so frustrated with the lack of response from his 2-Year partners that he decided to complete the project without them and refused to put their names on the report. However, he submitted the report a full week before it was due. This was only a two-week project, meaning he wanted to complete the project in half the time! The 4-Year instructor made it extremely clear that his timeline was not allowed to supersede the timeline dictated by

the instructors. Once this understanding was reached, the student backed down and this team actually did quality work *together*.

The student survey also asked about the challenges and positives from the experience. Half the students indicated frustration with finding meeting times. The instructors had anticipated this and tried to alleviate it by having no class during those 2 weeks. Most of the 2-Year students had no class during the time of the 4-year class due to an institutional scheduling tradition. Nonetheless, one hour was not enough time for the 10-minute commute there, parking, meeting, 10-minute commute back, and parking again. This is a logistics issue that will need to be resolved in the future.

Students expressed frustration with the lack of time for the project. It was made very clear that this was a pilot project to identify the issues and solve them before a "full-scale" attempt. Even knowing this, the students really enjoyed the opportunity to work with a real company and other students with different perspectives and wanted more time for it. The 4-Year students were most frustrated (over half complained loudly about this) because they are used to full semester long course projects.

Students were thrilled with the opportunity to work on a real problem for a real company. Many of the 2-Year students had never been in a manufacturing facility before. Practically every one of them noted this as the most valuable part of the project. Even about half of the 4-Year students noted this even though most of them have already had several course projects involving a real problem with a real company.

About a third mentioned specifically that they appreciated the opportunity to work with the students from the other school.

Overall the students were thrilled with the project. One wrote "Let's do this again!" and another wrote "This was a great idea!" Even those who found it challenging appreciated the experience. One noted the scheduling issues made this "a trying experience, but rewarding."

Industry Feedback. Industry was extremely supportive of the collaboration. In general, they believed this was a valuable experience for the students and virtually all companies indicated they gained value from the students. As mentioned above, three companies had already implemented student recommendations by the end of the project.

All the companies are interested in doing this again with a longer time frame. Furthermore, we have already been getting unsolicited emails from other companies who heard about the collaboration. They want to get in on the action in the future. Industry indicated this was a very valuable experience.

Conclusions

Challenges. We knew going in that the major hurdle would be logistics. To even begin this collaboration, the dean of the 2-Year school had to move the course identified to the fall semester. It has always been taught in the spring before.

We will need to seriously address the issues with finding meeting times. Currently we are brainstorming to find more ways to alleviate this issue. This includes looking into possible digital meetings. This, however, does not address the secondary goal of helping students feel comfortable with the other campus.

One of our biggest headaches was parking. It is relatively easy for the 4-Year students to get a temporary parking pass at the smaller 2-Year school. But parking passes at the much larger 4-Year school are harder to obtain. There are multiple parking lots, not just one, so a general pass is not workable. The deans are very supportive of this collaboration and are currently exploring options for solving this issue.

A challenge that we did not encounter, but could be a problem for some, is a disconnect between instructors. In this instance, both instructors were excited for the opportunity, communicated fairly well right from the start, and had similar mindsets. If this were not the case the collaboration would likely have had a very different result. It is important for the students to see us model what we are trying to teach. In this case that was easy. Both instructors clearly valued their counterpart which provided a positive example for students to follow.

Future Plans. Despite the challenges, both institutions see this as a major win-win. We are determined to find solutions to the major hurdles. We expect to expand this collaboration next year with a longer time frame for the project. We already have a slate of companies willing to provide projects.

Acknowledgements

This work evolved from discussions initiated by Mr. Jason Bruns, director of the Minnesota State Engineering Center of Excellence. His continuing support of the collaboration is greatly appreciated, as is the ongoing support of the respective deans: Dr. Mike Mendez, Dean of Skilled Trades and Industry at St. Cloud Technical and Community College; Dr. Adel Ali, Interim Dean of the College of Science and Engineering at St. Cloud State University; and Dr. Dale Buske, Interim Associate Dean of the College of Science and Engineering and Interim Director of the School of Computing, Engineering and Environment at St. Cloud State University.

References

[1] D. Gardner (commission chair), "A Nation At Risk: The Imperative For Educational Reform," *Open Letter to the American People, National Commission on Excellence in Education*, 1983. Archived: https://www2.ed.gov/pubs/NatAtRisk/index.html.

[2] R. Ralph, "Post secondary project-based learning in science, technology, engineering and mathematics," *Journal of Technology and Science Education*, vol. 6, issue 1, pp. 26-35, 2016.

[3] J. Cuseo, *Collaboration Between Schools & Colleges, a.k.a., School-College Partnerships,* University of Wisconsin website, 2008. Retrieved 5 October, 2018 from: https://www.uwc.edu/sites/uwc.edu/files/imce-uploads/employees/academic-resources/esfy/_files/collaboration_between_schools_and_colleges.pdf.

[4] B. Tabrizi, "75% of Cross-Functional Teams Are Dysfunctional," *Harvard Business Review Online*, 2015. Retrieved 8 October, 2018 from: https://hbr.org/2015/06/75-of-cross-functional-teams-are-dysfunctional.

[5] A. Randel, "A Practical Guide to Cross-Functional Work," *Medium: The Ready*, 2017. Retrieved 8 October, 2018 from: https://medium.com/the-ready/a-practical-guide-to-cross-functional-work-e94f7f51d41a.

[6] M. Gonzalez-Carrasco, J.F. Ortega, R. deCastro Vila, M. Castaner Vivas, J. San Molina, and J.M. Bonmati, "The Development of Professional Competencies Using the Interdisciplinary Project Approach with University Students," *Journal of Technology and Science Education*, vol. 6, issue 2, pp. 121-134, 2016. Retrieved 7 October, 2018 from: http://dx.doi.org/10.3926/jotse.196.

[7] M. Itkonen, K.E. Ekman, and I. Kojo, "Murjottelu – interdisciplinary training campaign for industrial design and engineering students," *European Journal of Engineering Education*, vol. 34, issue 3, pp. 263-271, 2009.

[8] D. Shadlinger and D. Toomey, "Knacktive: Answering a Call for More Interdisciplinary, Collaborative, Educational Experiences," *Journal of College Teaching*, vol. 62, issue 2, pp. 55-61, 2014.

[9] J. Samuel, C. Spackman, L. Ruff, J. Crucetti, S. Chiappone, and L. Schadler, *A Research University and Community College Collaboration Model to Promote Micro-manufacturing*

Education: Preliminary Findings, Proceedings of the 44th North American Manufacturing Research Institution of SME, vol. 5, pp. 1168-1182, 2016.

[10] A. Enriquez, Pong, Wenshen, H. Shahnasser, H. Jiang, and C. Chen, *Engaging Underrepresented Community College Students in Engineering: A Model of Collaboration between Two-year and Four-year Institutions*, Proceedings of the 119th SEE Annual Conference and Exposition, 2012.

[11] M. Davis, "Collaboration Between Universities and Community Colleges Offer New Educational Opportunities for Students," *Public Purpose*, summer 2009. Retrieved 5 October, 2018 from AASCU (American Association of State Colleges and Universities) website: http://www.aascu.org/MAP/PPMDefault.aspx?id=230#2.