

The Engineers' Orchestra: a Conductorless Orchestra for Developing 21st Century Professional Skills

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Abstract

Reaching one's full potential embodies much of human aspiration, yet in general, the student engineer is not born an experienced team player or communicator, both necessary for effective leadership. In fact, engineers may be predisposed to the opposite side of the psychological spectrum. Research has shown they often suit a cognitive style known as field-independence, preferring solitary work and non-social environments. But industry and government continue to call for the cultivation of professional skills, i.e., leadership, teamwork, and communication, due to the increasing size and complexity of 21st century engineering projects.

As is well-known anecdotally, engineering schools harbor large percentages of musicians. Brain research has shown that music-making has endowed these engineer-musicians with neurological benefits that already prime them for leadership, teaming, and communicative roles; thus they are excellent contenders for meaningful professional lives.

A project-based learning lab that builds upon the musical ability of student engineers can help cultivate these professional skills. Such a lab now exists in the form of a conductorless orchestra—an ensemble, minus conductor—that features engineering students in collaborative, communicative, and leadership roles. A four-year study tracking professional skills in an undergraduate conductorless orchestra 'lab' demonstrates engineering student development in leadership, teamwork, and communication. This makes sense since they have to practice the latter two for successful performances. Yet effective teamwork and communication constitute two widely acknowledged traits of skilled leadership. Why not give our engineer-musicians an orchestra to call their own—a conductorless orchestra where they practice these professional skills in a large team environment—while doing something they love—music? A rationale and resources for a conductorless orchestra now exist that can apply to diverse engineering schools, large and small, throughout the United States.

Impetus

Professional skills—leadership, teamwork, and communication—can make or break a purposeful life. Practiced effectively, they augment the virtues distinctive to an individual, thus growing character and agency for the better good. Given the centrality of technology today, engineering students will help shape our future, significantly. Yet often they lack the professional skillset to reach the greatest promise in their careers and as citizens. How can professional skills be developed through experiential practice? Blurring the line between art and science offers one route via creative engagement: playing in a conductorless orchestra where students practice leadership, teamwork, and communication week-in and week-out. The only conductorless orchestra in the world composed of engineers currently resides at Olin College of Engineering. Can its rationale and methods translate elsewhere? Developed over 17 years, the orchestra has evolved successive blueprints that feature core values with clear expectations, team-based organizational structures, and constructive feedback. Our ever-evolving blueprints and accompanying materials can help situate the conductorless orchestra within the engineering curricula of other schools, providing useful resources for enduring growth: actionable blueprints that speak to different stages of development, orchestral arrangements, videos, concerts, and workshops. This is a bold goal, yet the infrastructure, model, and methods—ever progressing—are all there, backed up by 17 years of sustained growth.

The Olin Conductorless Orchestra

Developing Students

Reaching one's full potential embodies much of human aspiration, yet in general, the student engineer is not born an experienced team player or communicator, both necessary for effective leadership. In fact, engineers may be predisposed to the opposite side of the psychological spectrum. Research has shown they often suit a cognitive style known as field-independence, preferring solitary problem-solving, unambiguous answers, and non-social environments. (Witkin and Goodenough 1977, Seat *et al.* 2001, Osburn and Stock 2005) But industry and government continue to call for the cultivation of professional skills, due to the increasing size and complexity of 21st century engineering projects. (Grinter 1955, O'Neal 1990, NSF 1996, NAE 2005, Miller 2008)

Significantly, a student conductorless orchestra at Olin College of Engineering has evolved methods for distributed leadership through which students experience peak performance, teamwork, and effective communication. Such an orchestra exerts singular demands on each individual during rehearsals and concerts: the musicians must take initiative to diagnose problems, communicate possible solutions, and test/implement the discussed changes. In so doing, they build scaffolding for effective teamwork.

But why not just teach these skills in other coursework? Why focus on engineer-musicians? Recent work in brain research suggests these students are already primed for leadership, teamwork, and communication. Not only do musicians exhibit linguistic advantages over non-musicians (Patel 2003, 2007; Sammler *et al.* 2009), but they also have a relatively larger cerebellum and corpus callosum than non-musicians. (Hutchinson *et al.* 2003, Lee *et al.* 2003) An increase in the size of the cerebellum suggests that its role in cognitive function and motor coordination is enhanced due to structural changes in neurons and their synapses. (Holtmaat and Svoboda 2009) A larger corpus callosum suggests more interaction and transfer between the brain's two hemispheres, since the corpus callosum connects both hemispheres. (Hutchinson *et al.* 2003, Lee *et al.* 2003) It therefore makes sense for educators to nurture and support their engineer-musicians; the raw material already exists. Why not give them an orchestra to call their own—a conductorless orchestra where they practice leadership, teamwork, and communication in a large team environment—while doing something they love—music?

Augmenting an Engineering School

The Olin Conductorless Orchestra (OCO) is the oldest group at Olin College and provides an enduring example of what an engineering school can represent. The orchestra has been a vehicle for talented students studying engineering since 2002, and shows the Renaissance side of their education. Its concerts often take place in front of sizable groups of people (e.g., OCO's 2017 Great Hall concert at Cooper Union in New York City), thus reflecting positively on the college's multidisciplinary approach to educating engineers. OCO's performances continue to attract prospective students, thereby contributing to the institution's admission process in building the student body, which in turn helps build the college.

External Impact

As an initial step towards external impact, a book chapter, "The Engineers' Orchestra: a conductorless orchestra for our time" was published by Springer Nature in *Creative Ways of Knowing in Engineering* (Baraiktarova and Eodice, eds., January 2017). Follow-on steps included OCO's 2017 Great Hall concert at Cooper Union in New York City and a local sold out concert at Powers Hall in Needham, MA. These performances demonstrated OCO's potential with respect to audience response. Both concerts received standing ovations—something unexpected—thus showing the potential allure of an Engineers' Conductorless Orchestra to external audiences. Specifically, this student conductorless orchestra brought a New York audience to its feet. Though it was not OCO's best 2017 concert, the performance connected viscerally and crossed the footlights.

As has repeatedly been observed, students talented in math, science, and engineering are often talented in music, suggesting that a viable musical presence within an engineering curriculum makes sense. A first approach towards introducing the conductorless orchestra model to other schools will occur at the 2019 ASEE Zone 1 International Conference in Niagara

Falls, New York. The photo below captures the OCO students who will be performing on April 12, 2019, for the ASEE conference.



A second milestone will be an accessible website hub that offers scaffolding, materials, and tools to support the conductorless orchestra model at other engineering schools.

A Conductorless Orchestra Hub

A summer grant from the 2019 Innovation and Research Fund at Olin College will enable the creation of an online conductorless orchestra hub with resources to help schools (regardless of size) implement their own conductorless orchestras. The Hub will be available to any interested party by simply sending a request email to the author. Since Olin is a small school, OCO numbers only 12-24 players who often select repertoire composed for 90+ players. I then re-orchestrate their selections to create the best group sound possible, given a nonstandard instrumentation (the traditional balance among winds, brass, and strings is askew). As a result, a large library of 127 orchestral arrangements ranging from Bach to Game of Thrones exists that can be accessed by others via an online Engineers' Conductorless Orchestra Hub. The Hub will also include organizational blueprints, practice strategies, rehearsal/concert videos, and eventually, outreach opportunities such as workshop/concerts involving OCO musicians in tandem with engineer-musicians at peer schools. These will not only help emerging conductorless orchestras thrive, but also benefit students at participating schools by providing opportunities to meet and work with engineer-musicians at other institutions.

Impact with respect to Leadership, Teamwork, and Communication: a 4-year study

Impact with respect to students

The Olin Conductorless Orchestra is a Project-Based Learning (PBL) course where students operate the classroom, and the professor contributes as guide-on-the-side. In helping to run rehearsals, students develop professional skills in a large team environment. Do we have any evidence to support this claim?

In April 2015 I devised an anonymous questionnaire (administered May 1, 2015) to assess whether OCO had made a difference for our students with respect to leadership, teamwork, and communication.

Six questions comprised the questionnaire, each of which started with the contextual clause “From the time you started OCO till the present time ...” :

- 1A) has OCO made a difference for your **understanding of leadership**?
- 1B) has OCO helped you **develop your own leadership skills**?
- 2A) has OCO made a difference for your **understanding of teamwork**?
- 2B) has OCO helped you **develop your own teamwork skills**?
- 3A) has OCO made a difference for your **understanding of effective communication**?
- 3B) has OCO helped you **develop your own communication skills**?

Students answered each question by selecting from five possible responses:

1. Not at all
2. A bit
3. Moderately
4. Yes
5. Significantly

The percentage results given below represent the number of responses marked “Moderately”, “Yes”, or “Significantly”, divided by the number of respondents, where the number of respondents ranged from 14 to 19, depending on the given year. The students in OCO typically include first-years, sophomores, juniors, and seniors.

For the Spring 2015 orchestra, the tabulated responses were as follows:

- Regarding teamwork, 79% of students indicated that OCO made a difference in their understanding of teamwork and 84% indicated that OCO helped them develop their own teamwork skills.

- Regarding communication, 84% indicated that OCO made a difference in their understanding of effective communication and 79% indicated that OCO helped them develop their own communication skills.
- Regarding leadership, 74% indicated that OCO made a difference in their understanding of leadership and 47% indicated that OCO helped them develop their own leadership skills.

In short, students benefited from OCO in terms of teamwork and communication, and less with respect to leadership. This made sense since the students had to work as a team (after all they're a conductorless orchestra without a de facto leader). To do a good job, these students had to get better at teaming and communicating with one another. Since OCO helped grow their understanding and personal development of teamwork and effective communication—two widely acknowledged traits of skilled leadership—it's telling that in written comments, 8 of the 19 students expressed “we are all leaders”, or a close parallel.

The same survey was then administered over the next three academic years. Table 1 captures the results.

Table 1

Question #	Spring '16	Spring '17	Spring '18
1A: ... understanding of leadership	83%	86%	88%
1B: ... develop [my] own leadership skills	77%	79%	82%
2A: ... understanding of teamwork	78%	86%	81%
2B: ... develop [my] own teamwork skills	78%	79%	88%
3A: ... understanding of effective communication	83%	86%	100%
3B: ... develop [my] own communication skills	78%	93%	88%

These results show growth in student understanding of leadership, development of their own leadership skills, and student understanding of effective communication. Student development of their own communication skills grew from Spring '16 to Spring '17, and still reached a comparably high percentage (88%) in Spring '18.

Though the percentages for the teamwork questions remained respectably high, they were somewhat lower than the leadership and communication evaluations for Spring '16, Spring '17, and Spring '18. Two possible reasons for this result are:

1. Students at Olin work in teams for a number of core courses throughout their undergraduate years, and

2. Teaming strategies have increasingly infused courses since Spring 2015, when the study began.

These reasons suggest students did not ascribe as much understanding or development of teamwork to OCO. A corollary to this remark would be that OCO students brought the teaming skills they had learned in other courses to bear on their conduct in OCO rehearsals, practice groups, and performances.

Impact with respect to the home Engineering School

The Engineers' Orchestra links synergistically with Engineering Admissions since the engineering applicant pool is often strong in music. It supports the efforts of the Post-graduate Planning staff to successfully place students as interns and professionals in engineering positions: Industry has been calling for skills in leadership, teamwork, and communication for over 20 years now. The Engineers' Orchestra supplements the Arts, Humanities, and Social Sciences programs that teach effective communication for students in engineering colleges and universities. It is synergistic with engineering courses that have significant teaming components, as well as leadership positions manifested throughout the engineering community, from engineering clubs like Electric Motor Sports to top administration and management.

Concluding Remarks

Engineering schools offer a seminal environment for planting the conductorless orchestra within their curricula. In particular, Olin College has taken bold chances since its inception. The fact that such a small school has successfully sustained a conductorless orchestra for 17 years speaks to the effective sustainability of the conductorless orchestra model for other institutions. Learning from our successes and failures, OCO has evolved to a higher plane from year-to-year, as chronicled in (Dabby 2017) and YouTube recordings, e.g., the last movement from the Dvorak Ninth Symphony http://bit.ly/OCO_Dvorak9th and *An American in Paris* <https://www.youtube.com/watch?v=BA5F48usRlo>.

As is well-known anecdotally, engineering schools harbor large percentages of musicians. Neuroscience suggests they are already primed to lead, team, and express. Character virtues such as integrity, honor, and decency align with effective teamwork and communication, all of which enable leadership whereby a community of practice finds value in, and makes sense of, their efforts. (Drath and Palus 1994)

Humility and gratitude find particular resonance in a conductorless orchestra. Multiple talent levels exist in music; as good as one is, there is likely someone better. Without humility among its musicians, a conductorless orchestra cannot grow. An openness to learn from others provides fertile soil. Students get this. Each brings something to the table. They speak to

audiences with gratitude—for the contributions of peers, for a concert well-played, and for music itself—the “balance,” “emotional release,” and “joy” it gives, or as one put it: “No Music, No Life.”

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