Self-Awareness of Student Leaders in an Experiential Undergraduate Engineering Clinic Program

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Introduction to Clinic Program

The engineering clinic program at Harvey Mudd College was started in 1963, six years after the college first opened its doors [1]. It was different from other capstone projects at the time as it provided students with real problems rather than ones invented by professors but was still kept in-house so that the intellectual experience could be overseen [1]. The ingenuity of its design led Harvey Mudd to become the model for other institutions looking to create a similar program [1]. Each clinic sponsor comes up with an academic-year-long project, pays Harvey Mudd approximately $50,000, and identifies one or more of its employees to work as liaisons with the student team. Though the project idea is determined by the sponsor, the project deliverables are discussed and agreed upon by the student team and the liaisons under the guidance of a faculty advisor. Since the clinic program began, "over 1,500 projects have been completed for more than 450 corporate, national laboratory and agency sponsors" [2].

All students majoring in engineering are required to spend one semester during their junior year and two semesters during their senior year participating in the clinic program. They read over project descriptions given by the sponsors and indicate their top choices to the engineering department as do the faculty advisors. The department then coordinates student teams and assigns faculty advisors. Each team is made up of four to six students who are undergraduate junior and senior students. There are typically more seniors on the team than juniors. There are different junior students working in the fall semester than in the spring semester. The team works "under the guidance of a student project manager (team leader), a faculty advisor and [one or more liaisons] from the sponsoring organization" [2].

The clinic program has used a "non-explicit" approach to leadership education, meaning leadership has been embedded in the program but has not been explicitly taught [3]. Senior team members let their faculty advisor know at the onset of the project if they are interested in being a team leader (no previous leadership experience is necessary), and the faculty advisor ultimately selects the team leaders for the year. Teams typically have one leader in the fall semester and another in the spring semester. During the 2016-2017 school year, the engineering clinic program used a more explicit approach to teaching leadership by having team leader meetings. There were three to four meetings each semester for student team leaders to meet and discuss upcoming deadlines, new ideas, and any concerns; however, there were no formal leadership training sessions or professional development workshops for team leaders.

While there are other departments at Harvey Mudd and other institutions that have clinic programs, only the engineering clinic teams were surveyed. Because the program uses a non-explicit approach to leadership, evaluations must be performed by way of assessment tools, such as surveys and interviews. See Appendix A for previous assessments of the clinic program. This study seeks to evaluate team leaders' self-awareness in the engineering clinic program by comparing their perception of their leadership styles to how they are perceived by their team members. In this way, the college may examine potential areas for improvement with respect to creating more self-aware leaders.

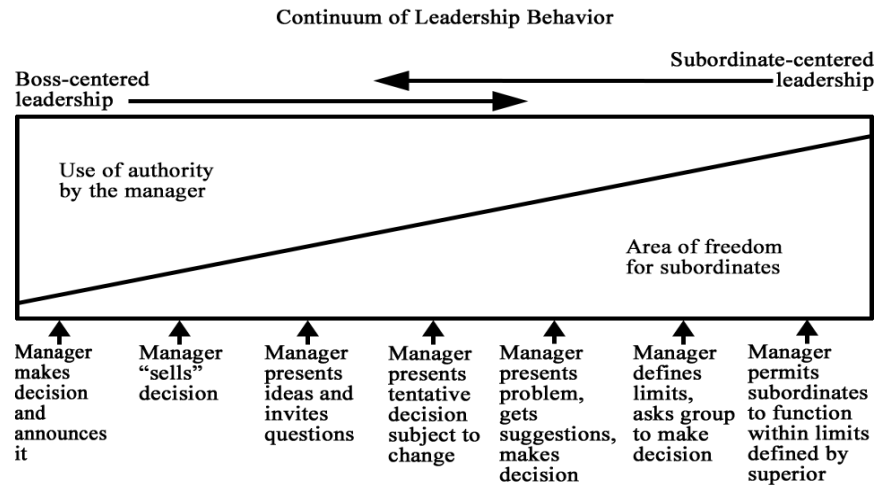Introduction to Leadership Styles

Figure 1: The Tannenbaum-Schmidt continuum [4] adapted to form a six-point scale.

The work of leaders is "influence the behavior of an individual or group" [5], and more specifically within the clinic program, their job is to motivate team members to achieve the goal of the clinic project. To do this, they must communicate, approach problems, and make decisions differently based on what is needed to reach this goal. There are a variety of styles of leadership to use in different situations and, similarly, a variety of models of leadership to describe these styles. There is the Hersey-Blanchard model that describes a leader's style and follower's readiness based on the extent to which the leader explains what needs to be done and the extent to which they communicate with others as well as the ability and willingness of a follower [5]. Other models include Fiedler's Contingency model that describes leadership effectiveness based on leader-member relations, task structure, and position power [6] and the Tannenbaum-Schmidt continuum. The Tannenbaum-Schmidt continuum (shown in Figure 1) was determined to be easy to understand and use at a college-level with no prior leadership, thus this study uses an adapted version with six leadership styles: tell, sell, test, consult, join, and delegate. These styles are summarized in Table 1 with number values assigned for the purpose of surveying. Since leadership is situational, no "right" style can be determined, so these styles were used to analyze self-awareness of leaders.

Style	Number	Description	Phrasing
Tell	1	One-way communication, no feedback, leader already made decision	"I want you to do this."
Sell	2	Mostly one-way communication, leader accepts questions, leader uses persuasion	"Here are the reasons why you should do this."
Test	3	Leader is pretty sure of decision already but open to feedback, leader values input, leader makes final decision	"This is what I want us to do. Does anyone see any potential flaws?"

Consult	4	Open communication, leader asks for input, leader makes final decision	"How can we solve this?"
Join	5	Leader makes clear decision boundaries, leader asks for input, leader makers decision with team	"Let's work together to solve this."
Delegate	6	Leader makes clear boundaries, team makes decision without consulting leader	"You two figure this out."

Table 1: Summary of the six leadership styles.

Self-Awareness in Leadership

Self-awareness is vital to authentic leadership, and authentic leaders serve as models for authentic followers who are more trusting and engaged and have more "sustainable" and "veritable performance" [7]. This is because self-aware leaders are more receptive to feedback from others and better at incorporating that feedback into their actions [8]. They are also better at understanding their strengths and identifying places where they can improve [9]. Those who have an accurate perception of themselves are characterized as being intelligent and needing achievement and control, which allows them to better act on the feedback of others and adapt their leadership behaviors, which make them more effective leaders [10] [11].

Self-awareness is composed of two parts: understanding yourself and understanding how others see you [9]. Often only the first part of self-awareness is analyzed. Leaders take personal assessments, such as those that figure out their Myers-Briggs personality types, in an effort to identify their strengths and weaknesses. While this is one component of self-awareness, the second part of the self-awareness requires more attention because it "deals with how leaders become 'in touch with' or are able to accurately read (1) the emotions, thoughts, and preferences of others and (2) the influence they are having on others—how others experience their leader behavior" [9]. It is this second part that forces leaders to consider others when considering their own strengths and weaknesses [9].

The goal of this study is to analyze the self-awareness of leaders in the clinic program in terms of their leadership style. In similar studies [10] [12], three categories have been used for leaders: underraters, overraters, and those in-agreement. Because leadership is situational, there is no "good" style, so leaders are categorized as either accurate or inaccurate in their self-perception. Thus, those who rated themselves closer to the tell side of the spectrum than their team did and those who rated themselves closer to the delegate side of the spectrum than their team did are placed in the inaccurate perception category.

Data Collection

The leadership methods used, as well as the teams' perceptions of the leaders in the engineering clinic program, are necessary to better understand the leaders' self-awareness. To this end, an

anonymous survey of the clinic students was done. Participants were asked the following questions:

1. What clinic team are you on?
2. What leadership division has your team used?

Based on the answer to question two, the participant would have to read the summary of the six leadership styles in Table 1 and answer the following about each leader they had:

3. Were you this leader?
4. Numerically describe the leadership style this leader used most often where 1 is tell, 2 is sell, 3 is test, 4 is consult, 5 is join, and 6 is delegate.

Anyone who was not on the team for the length of the project (such as junior team members) was asked to put 0 for team leaders they did not have, and those results were excluded from the team's perception of that leader. While the survey asked which clinic team the participant was on, this was only used to link team leaders with their team members, and the information is not included in the collective results.

The survey was emailed to all current engineering clinic team members. Any team that had all their current members fill out the survey was eligible to be randomly selected to win a small monetary prize. To be used as a data point, a team needed to meet the following two requirements: (1) at least one leader filled out survey and (2) at least two team members who worked under that leader filled out survey. A data point was generated any semester where this was true. 89 people filled out the survey. Out of the 27 engineering clinic teams during the 2016-2017 school year, 13 teams fulfilled the requirements above for each of their team leaders, and 2 teams fulfilled these requirements for the spring semester leader alone. 10 teams had some response, but not enough participants to generate a data point. 1 team had no responses. Based on the response conditions, 29 data points were generated, representing at least one leader from 56% of the engineering clinic teams.

Results

To determine the team's perception of a leader, the average response was used, and a leader was deemed to have an accurate self-perception if they said the style they used was within one standard deviation of the average style the team provided (since each style was given a numerical value previously shown in Table 1). A similar approach was used in [12]:

Self-ratings were compared to mean direct reports' ratings instead of to each individual subordinate rating because we believed, as did Wohlers and London (1989), that 'when combined, ratings tend to match the target managers' views of selves more than target managers' views match any one coworker's ratings' (p. 251). In addition, several studies have indicated that the average of ratings is more reliable than a single rating (French & Bell, 1978 Mount 1984; Latham & Wexley, 1981; Miner 1968).

Figure 1 shows the results of the leaders' self-perceptions compared to the way their teams perceived them. The leaders whose self-perception was more than one standard deviation greater than the team perception saw themselves as using a style closer to the delegate-end of the spectrum than their team saw them. Those whose self-perception fell below one standard deviation from their team perception saw themselves as using a style closer to the tell-end of the spectrum than their team saw them.
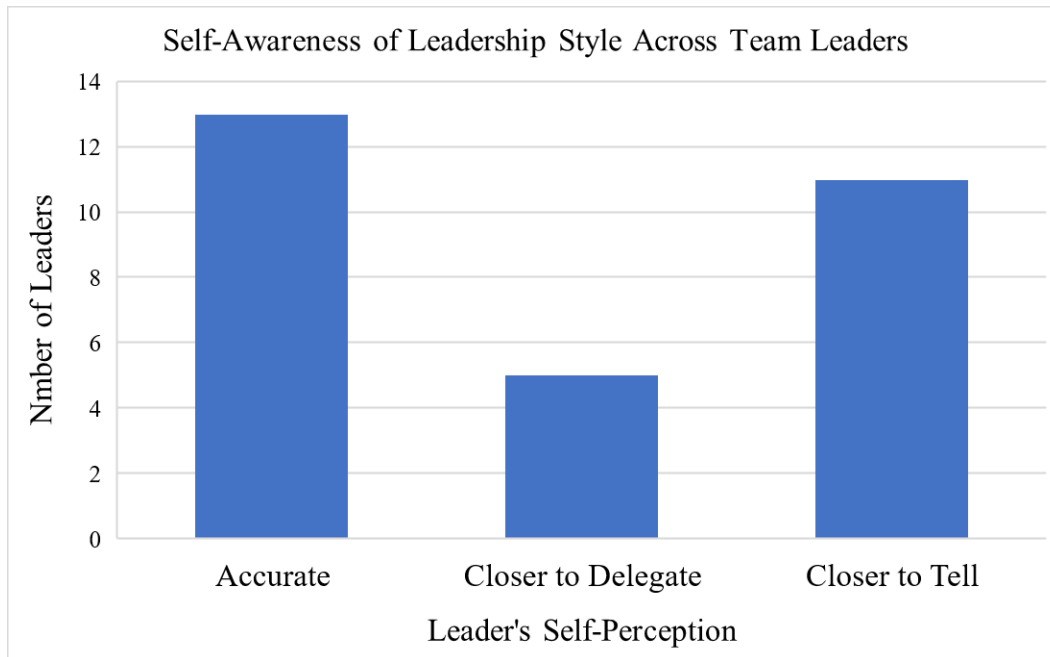
Figure 2: The categorization of leaders' self-awareness across the clinic program.

Figure 2 shows the categorization of the 29 team leaders. 13 had an accurate self-perception, 5 believed themselves to be using a style closer to the delegate-end of the spectrum, and 11 believed themselves to be using a style closer to the tell-end of the spectrum.

To ensure the leaders are correctly categorized (i.e. those in the "Closer to Delegate" group actually rated themselves closer to the delegate-end of the spectrum), the mean overall perception of self for each group is compared to the mean overall perception of the leader for each group. The results are shown in Table 2.

	Average Self Perception of Leader	Average Team Perception of Leader
"Accurate" Group	4.0 (Consult)	4.1 (Consult)
"Closer to Delegate" Group	5.4 (between Join & Delegate)	4.0 (Consult)
"Closer to Tell" Group	3.6 (between Test & Consult)	5.0 (Join)

Table 2: Average self and team perceptions of leaders in each group.

Those in the "Accurate" group had the same perception of themselves as their teams did. Those in the "Closer to Delegate" group perceived themselves as being closer to the delegate-end of the spectrum than those in the other two groups. They saw themselves using the join and delegate styles while their teams saw them using the consult style. Those in the "Closer to Tell" group perceived themselves as being closer to the tell-end of the spectrum than those in the other two groups. They saw themselves using the test and consult styles while their teams saw them using the join style.

As mentioned in the sections on leadership styles and self-awareness in leadership, there is no "good" end of the spectrum, so anyone not in the accurate category is deemed to have an inaccurate self-perception. Those in the accurate category are said to be self-aware while those in the inaccurate category are said to be not self-aware. Figure 3 shows the accuracy of leader self-perceptions (i.e. the overall self-awareness of leaders) across the clinic program.
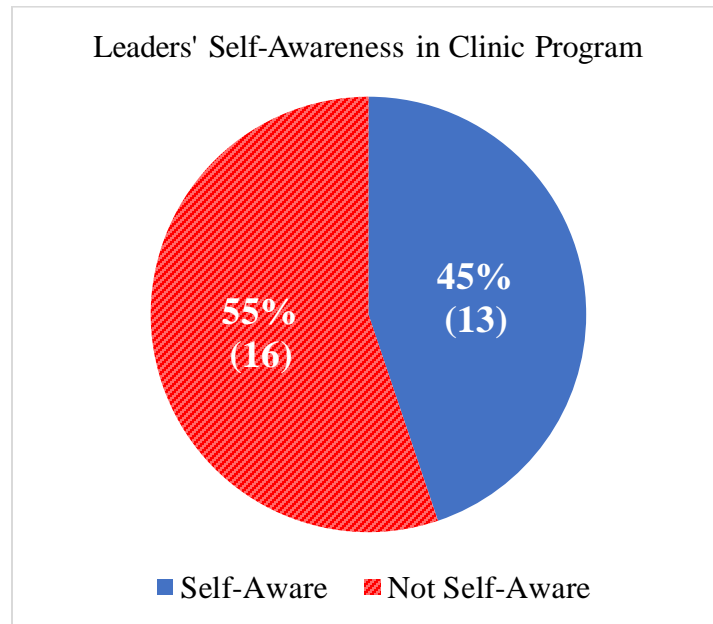

Figure 3: Desired leadership styles with responses from leaders and non-leaders.

Figure 3 shows that 45% of clinic team leaders are self-aware when it comes to their leadership style while 55% are not self-aware of their leadership style.

Discussion

In Figure 3, we see that 55% or 16 team leaders did not accurately perceive their own leadership style while 45% or 13 team leaders were self-aware in that they had an accurate perception of their leadership style. Only 13 of the 29 leaders accurately described their most used leadership style. 5 leaders believed themselves to be closer to the delegate-end of the spectrum than their teammates believed them to be while 11 leaders thought they were closer to the tell/sell style than their teammates thought they were. Thus, the common trend for the engineering clinic team leaders is to assume they're being more "boss-centric" as the Tannenbaum-Schmidt continuum calls it in Figure 1 (i.e. using more tell, sell, test methods) than their teammates believe them to be.

Even though the average team perception of leaders in each of the three groups was consult or join, 11 of the 29 leaders believed themselves to be between test and consult while their teams thought they were using more of a join style. As the clinic program at Harvey Mudd emphasizes working together and including others on the team in the decision-making process, many team leaders likely associate being towards the delegate-end of the spectrum as being a "better"

leader. Therefore, the number of respondents labeling themselves as closer to the tell-end of the spectrum makes sense as Harvey Mudd students' "impression of their own […] performance is often lower than reality" [13]. It is this tendency for students to look down on their own performance (i.e. feel that they are not including members in all decisions enough) that results in leaders seeing themselves as closer to tell/sell while their teammates actually see them far closer to the desired consult and join styles.

Implications and Future Research

These findings imply that the clinic program needs to better explain to the team leaders what different leadership styles look like so that they can better identify their own use of leadership styles. Because situational leadership means different styles need to be used at different times, creating more self-aware leaders in this respect would enable them to better move between styles as the project situation changes, making them more effective leaders. For Harvey Mudd's engineering clinic program leaders to be exceptional leaders as described in the college's program educational objectives [14], they need more explicit training incorporated into clinic.

Based on the findings of this survey, the 2017-2018 clinic program has been enhanced to include more explicit leadership training. This includes a new 75-minute-per-week leadership seminar required of all junior students enrolled in clinic. The seminar covers the importance of situational leadership as well as topics such as communication, time management, project management, delegation, and behavioral styles. They perform group exercises and focus on project-based learning. The success of this additional leadership training in the clinic program will be evaluated based on questionnaires filled out by participating students at the start of the seminar, end of the seminar, and the end of their senior year after some of them have acted as clinic team leaders. The team leader meeting, previously used to discuss deadlines, ideas, and concerns, is also being modified to function more as a leadership workshop. The design, manufacturing, and management portion of the engineering major curriculum is also being strengthened so as to provide additional leadership and management training that complements the clinic program.

These improvements are a start to creating the exceptional leaders that Harvey Mudd seeks to create [14], but more work remains to be done. This survey looked exclusively at peer perception of student team leaders, but future studies could look at the liaison's perspective of the student team leaders. The study was also constrained by the anonymized data and small sample size. This limited the ability to examine additional trends that may be of further interest. Trends of interest would be the demographics of team leaders and the difference in leadership styles and perceived leadership styles of leaders of different genders or ethnicities. One suggestion would be to analyze male versus female leaders as some studies suggest there is no statistical significance between men and women being an underrater, accurate rater, or overrater [12] while others suggest that women tend to underrate themselves [15]. The perceived success of the different divisions of leadership may also help improve the clinic program for the future. It may be beneficial to the larger clinic program at Harvey Mudd to examine clinic leaders from other departments to see if there are any major differences when compared to the data from the engineering clinic program. This survey and the additional recommended evaluations as well as repeating the evaluations in the future will be critical to ensuring the best clinic program possible for students, faculty, liaisons, and alumni. As the clinic program at Harvey Mudd has also served

as a model for similar programs at other institutions around the world, seeking these improvements to leadership skill development might result in a widespread change to tomorrow's industry leaders.

Acknowledgements

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Appendix A

During World War II engineering education shifted from a hands-on approach to an emphasis on scientific analysis followed by a shift to outcomes-based education and then to engineering design (and specifically capstone projects) [16]. One such capstone experience is the engineering clinic program at Harvey Mudd. The clinic program is a "collaboration between industry and

Harvey Mudd that has been a hallmark of [the] institution for more than 50 years, [which] engages juniors and seniors in the solution of real-world, technical problems for industrial clients" [2]. The program was started by Professors Jack Alford and Mack Gilkeson in 1963, six years after the college first opened its doors [1]. They saw the excitement and ingenuity that went into building homecoming parade floats and saw a connection between that enthusiasm and their own enthusiasm for problems in industry settings [1]. Wanting to give students exposure and experience with professional projects, they began by giving freshman students industry-sponsored design projects, and after finding success there, created the clinic program for junior, senior, and master's level students [1] (though the college does not offer graduate degrees today). This program was different from other capstone projects at the time as it provided students with real problems rather than ones invented by professors but was still kept in-house so that the intellectual experience could be overseen [1]. The ingenuity of its design led Harvey Mudd to become the model for other institutions looking to create a similar program and its founders and other professors have traveled the world consulting on the creation of these similar programs [1]. Each clinic sponsor comes up with an academic-year-long project and identifies one or more of its employees to work as liaisons with the student team. Though the project idea is determined by the sponsor, the project deliverables are discussed and agreed upon by the student team and the liaisons under the guidance of a faculty advisor. Throughout the course of the project the students have regular meetings with the liaisons and faculty advisor in person or via Skype (typically weekly) to allow all parties to provide any project updates, discuss ideas or concerns, and amend project deliverables as necessary.

While there are other departments at Harvey Mudd and other institutions that have clinic programs, only the engineering clinic (or joint clinic projects between the engineering department and other math and science departments on campus) were surveyed. As the engineering department was where the clinic program got its start, evaluating its program lends itself to using prior assessments of clinic to provide context. In 1976, Harrisberger, et al. surveyed 11 students, 7 faculty, and 2 alumni about the importance of attaining certain skills, such as problem-solving, interpersonal awareness, professional ethics, and leadership skills. Respondents rated each skill on a scale of 1 to 4 where 1 was not too important, 2 was somewhat important, 3 was very important, and 4 was crucially important. Leadership skills were rated 3.6 by students, 2.9 by faculty, and 4.0 by alumni [17]. This shows that students see the importance of gaining leadership skills, and alumni believe it to be crucially important. Another survey in the same publication looked at the quality of the experiential program at Harvey Mudd compared to other traditional programs. When asked to rate each skill on a scale from 1 to 5 where 1 is poor and 5 is excellent, the quality of leadership skill development was rated 4.5 by students, 4.4 by faculty, and 5.0 by alumni while the traditional program saw average scores 2.0 from students, 1.0 from faculty, and 4.0 from alumni [17]. This means that historically, the experiential clinic program at Harvey Mudd has been more successful than traditional programs in terms of the quality of leadership skill development, but that there was still room for improvement. An evaluation of the program again in 1993 said that these early observations had been reinforced in the seventeen years between the evaluations [18]. As one of the program educational goals of Harvey Mudd is to "produce exceptionally competent engineers who will lead responsibly through their engineering judgment and practice" [14], it is crucial to regularly re-assess the success of the clinic program in meeting this goal.