Leadership Characteristics within the Making Community

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Leadership Characteristics within the Making Community

Makers are those who enjoy creating things and learning new skills, as well as interacting within a connected community[1]. Through the analysis of Makers as part of a larger study[2] a researcher had noticed the emergence of leadership traits within the Maker community. Leadership is a key quality for the engineer of the future[3]. Proactiveness, confidence, motivation, communication, coaching will be important skills for engineers so that they can effectively lead teams, adjust to change, and synthesize[4]. In National Academy of Engineering's *The Engineer of 2020*[3] future engineers are expected to be in position to influence "in the making of public policy and in the administration of government and industry." The Maker community offers a broad spectrum of individuals engaged in informal engineering and tinkering activities. This study explores leadership using a theoretical framework of competing values including relating to people, managing processes, leading change, and producing results[5]. The study relies upon artifact elicitation (based on photo elicitation[6]) with 40 of these Makers at four Maker Faires in the United States. The Artifact elicitation interviews were conducted at the Maker Faires in front of participants' inventions, where the Makers were asked to describe the invention and the process behind it. Using a theoretical framework of competing values[7, 8] and through parallel inductive-deductive analysis, the emergent themes among our sample of Makers include that they express leadership qualities of (1) innovators – they utilize different skillsets to develop unique products and solutions; (2) monitors – they evaluate projects and respond to results; (3) directors – they set goals and expectations of their projects and processes; and (4) producers – they are determined and possess a personal drive.

Introduction

Leadership is a highly desired trait among engineers according to the *Engineer of 2020*[3]. Engineers must "have developed skills in talking through material with peers, listening with real skill, knowing how to build trust in a working relationship, and providing leadership to group efforts"[9]. Engineers are expected to have strong teamwork and communication skills[10]. ABET requires for accreditation that engineering programs build upon their graduates' ability to function on multidisciplinary teams[11]. Engineers are expected to have the skills to manage, influence, think critically, make decisions, and collaborate[11].

In order to build upon research on the Making community and how engineering education can improve from the study of Makers, this study will analyze leadership in the Making community. We measured Makers on the Competing Values Framework[7, 8] (CVF). The CVF has been used to measure behavioral complexity within engineering student teams[5]. By applying this framework to the observed Makers the behavioral complexity of the community can be determined. Based upon which leadership roles are expressed within the community, educators may implement Making within the classroom to teach these leadership characteristics. Our research questions addressed:

> *RQ1:* Where do Makers fall on a leadership spectrum?
>
> *RQ2:* How does leadership observed in Makers relate to the expectations of ABET and the *Engineer of 2020*?

Literature Review

The research performed studied the community of self-described Makers. "The maker movement has come about in part because of people's need to engage passionately with object in ways that make them more than just consumers" [Doughtery 2012]. With the founding of *Make* magazine and the establishment of the Maker Faires there has been an opportunity for this community to interact on a large scale. A larger research effort is to see how Making can influence engineering education [Jordan and Lande]. As part of that research, this study focuses on leadership, the Maker Movement, and the Competing Values Framework.

A. Makers

Makers are often considered hackers, tinkerers, or DIYers. Makers range in expertise from novice to expert, each sharing an enthusiasm for building and creation. Making includes anyone that describes themselves as part of the community of tinkerers and DIYers[12]. One member of the community describes Making as having the ability to "think your way through a problem" and using creativity "because you don't have the resources or the equipment or the knowledge that is available out in the world"[13]. These Makers collaborate together to share information and experiences within the community[14]. This community populates maker spaces and hacker spaces[15] and gather with Makers in commercial spaces like Tech Shop[16] and Maker Bench[17]. This study works alongside a larger project to explore if Makers can be considered engineers and vice versa[2].

B. Leadership

Leadership can be defined as having the knowledge and skills to lead a team in achieving goals[3]. Engineering leadership is often determined by an analysis of what leaders in engineering do[18]. Leaders should be lifelong learners, be service-oriented, express a positive attitude, balance their lives, have confidence in others, synergize, and exercise self-renewal[19]. Leaders must also be able to: manage team tasks and relationships[20, 21]; think on a global scale[22, 23, 24, 25]; make decisions[22, 23, 26]; communicate effectively[20, 21, 23, 26]; and have knowledge of contemporary issues[23, 26]. Leadership instruction and experience assist a student in achieving the ability to lead teams[3].

C. The Competing Values Framework

The CVF allows categorization of leadership roles and expectations[5, 8]. Through a series of checks and evaluations individuals can be placed on a spectrum of leadership traits[7]. The framework is ingrained in a measure of behavioral complexity[5]. Individuals denoted as having high behavioral complexity are considered exceptional leaders due to their capability to operate in a wide range of behaviors[27]. The spectrum can be seen in Figure 1.

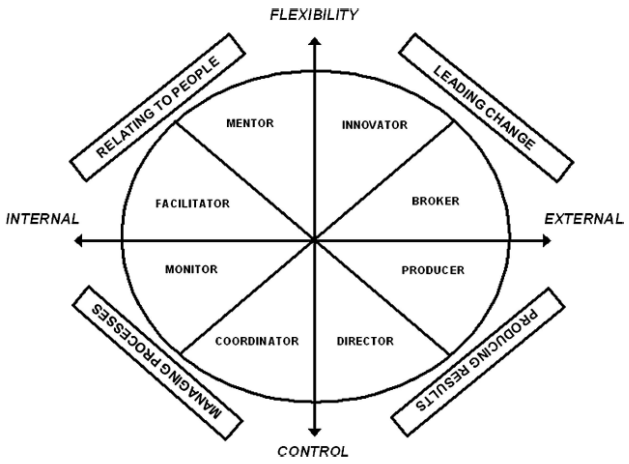

Figure 1: Leadership and profiles of the Competing Values Framework[7].

Across the graph are two axis, organizational focus (Internal-External) and adaptability (Control-Flexibility). Each value is considered opposite of the other end of the axis[5]. To a similar extent the quadrants opposite of each other represent conflicting values[7]. A company that is *Leading Change* focuses on a flexible structure and external focus; whereas it's opposite, a company that focuses on *Managing Processes*, has a controlled structure and internal focus. Leaders with high behavioral complexity are expected to express traits from three or four quadrants[5]. Table 1 provides a description of each quadrant and leadership role.

Table 1: Leadership quadrants and role descriptions[5].

Quadrant and Management Models	**Leadership Role**
Relating to People *Human Relations Model*	• Mentor: Acknowledges personal needs, develops people, caring, empathetic • Facilitator: Practices participation and teambuilding, focuses on consensus building, manages conflict and encourages participative decision-making
Leading Change *Open Systems Model*	• Innovator: Inspires, anticipates customer needs, initiates significant changes, new ideas, experiments, problem solves, adaptable • Broker: Sells ideas, influences decisions at higher levels, acquires needed resources, strong negotiator
Managing Processes *Internal Process Model*	• Monitor: Clarifies policies, expects accurate work, controls projects, monitors progress, develops measures and checkpoints • Coordinator: Brings order, plans schedules, provides stability, control and continuity
Producing Results *Rational Goals Model*	• Producer: Focuses on outside competition, emphasizes speed, hard work ethic, motivates people, initiates action • Director: Providing clear direction, clarifies priorities, communicates the vision, plans and prioritizes

In *Becoming a Master Manager*[8], each part of the Competing Values Framework is described in depth. Human relation roles emphasize on participation, conflict resolution, and consensus building. As a mentor a leader understands themselves and those around them, provides a source of communication, and develops others. As a facilitator they add to team building, encourage participative decision making, and manage conflicts. Open system roles focus on adaptation, creative problem solving, and change. As an innovator, a manager is keeping up with growth, thinking creatively, and directing change. As a broker they build and maintain resources, negotiate with others, and are involved in the exchanging of ideas. Internal process roles circle around defining responsibilities, measuring results, and documenting characteristics. As a monitor managers organize information, evaluate reports, and respond to results. As a coordinator a leader creates plans, organizes the team, and controls production. Rational goal roles clarify goals, utilize rational analysis, and take action. As a producer one must have personal initiative, motivate others, and manage stress and time. As a director managers have to take initiative, set goals, and delegate effectively. These roles focus on "leadership effectiveness"[8].

To understand an analysis using the CVF, Quinn provides an example look at a high-tech firm[7]. In his experiment Quinn's group consulted with executives of the company during a retreat in order to profile the organization on a spider graph (Figure 2). The profile ranges intensity in the representation of each leadership role from -3 to 3. In this profile 0 operates as an "average" representation among leaders. Traits that are weakly expressed—or not expressed at all—are negative in value. Traits that are highly expressed among the company executives are above the 0 mark.

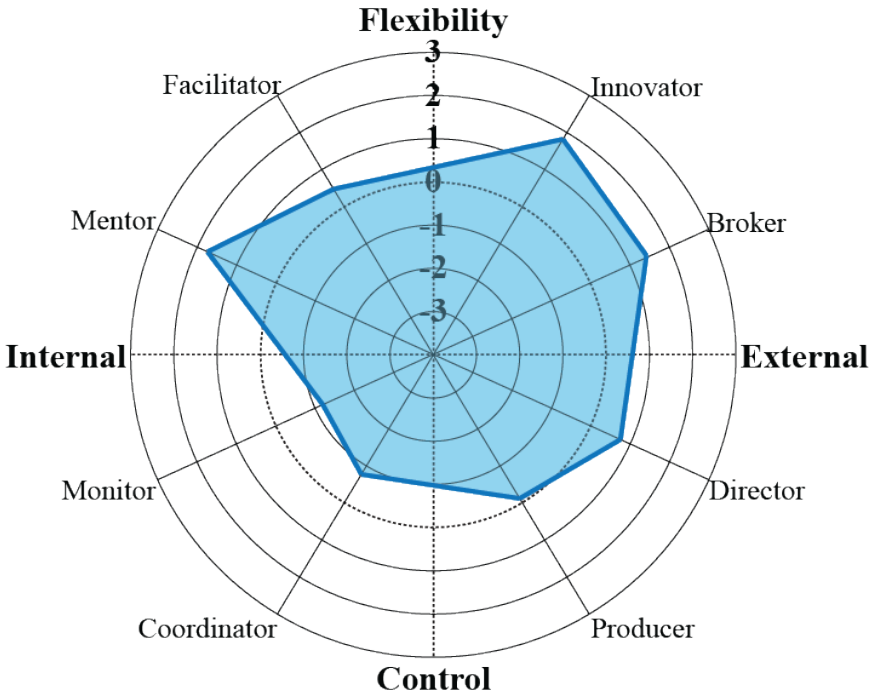

Figure 2: Profile of a High-Tech Firm[7].

As can be seen from Figure 2, the company excels in open systems and the ability to innovate, adapt, and acquire resources. On the opposite end, the company ranks rather poorly in its internal processes. Quinn notes that the executives agreed documentation and sharing of verbal information needed to increase[7]. From this diagnosis the company is able to reevaluate how it operates and make improvements where necessary.

Methods

This study relies on key methods utilized in gathering information on Makers and developing a method of assessing leadership traits within the Making community. As a basis the study collects information from artifact elicitation interviews conducted across four Maker Faires in the United States. Utilizing methods of evaluating individual leadership, Makers were then profiled and compared.

A. Participants

The study relied upon artifact elicitation interviews conducted with 40 adult Makers across four flagship Maker Faires in the United States. Artifact elicitation interviews, based on the method of photo elicitation[6], were gathered from the Makers in front of their showcase. These Makers were asked to describe their invention, including how it works and their process for bringing the idea to fruition. These in-person interviews help frame the knowledge, skills and attitudes of the Makers.

This study relied on interacting with Makers at the Maker Faires as part of a larger research project to study the pathways of Makers[2, 13, 14]. Participants were identified through a screening questionnaire. Stratified purposeful sampling was performed to select participants and maximize variation among the participants. The criteria for selecting participants was that they self-identify as a Maker and are adults (18 or older). Forty adult Makers participated in this study. Twenty-three were male; seventeen were female. The majority of participants identified as being a Maker for at least 5 years (23 participants), with ten of them being Makers for over 10 years. In addition, the majority of participants identified as having an engineering-related job/career (22 participants).

B. Instruments

Artifact elicitation interviews were conducted with the 40 participants in front of their exhibits at the Maker Faire festivals. These interviews were audio and video-taped for later transcription using NVivo qualitative coding software. The interview protocol relied on the physical artifact that the Maker created and brought to the festival. Participants were asked to describe the product and process behind the artifact, as well as any collaboration involved. An aim of the interviews was to elicit ways Makers participate in communities of practice. Table 2 shows sample questions that were asked in the interviews. These questions circled directly around knowledge, skills, and attitudes of the Makers.

Table 2: Sample artifact elicitation interview questions.

Can you tell me a little bit about what you brought to Maker Faire?	Knowledge, Skills
What (knowledge and skills) did you have to learn to make this invention? What is your process for designing your invention?	Knowledge, Skills
Who do you do your Making with?	Attitudes, Skills, Knowledge
How did you come up with the idea for this invention?	Attitudes
What is the next thing you're going to make, and why?	Lifelong Learning

C. Leadership Measurement

In order to assess leadership traits within the Making community a researcher utilized the descriptions of each role in Table 1. The questionnaire in Figure 3 was used by the researcher to give an example for each expression of leadership. The researcher then determined from the interviews when a Maker expressed one of the leadership roles.

In their Making, this person:

___ 1. Listens to the problems of team members/subordinates. (Mentor)
___ 2. Reviews and/or reflects upon project achievements. (Monitor)
___ 3. Influences decisions made at higher levels. (Broker)
___ 4. Does problem solving in creative, clever ways. (Innovator)
___ 5. Clearly defines areas of responsibility for team members/subordinates. (Director)
___ 6. Displays a wholehearted commitment to the job/project. (Producer)
___ 7. Facilitates consensus building in work-group sessions. (Facilitator)
___ 8. Protects continuity in day-to-day operations. (Coordinator)
___ 9. Compares records, reports, and so on to detect any discrepancies in them. (Monitor)
___ 10. Shows empathy and concern in dealing with others. (Mentor)
___ 11. Sets clear objectives for the project and/or team/work unit. (Director)
___ 12. Searches for innovations and potential improvements. (Innovator)
___ 13. Works on maintaining a network of influential contacts. (Broker)
___ 14. Insists on minimum disruption to the work flow. (Coordinator)
___ 15. Reflects high motivation for the role. (Producer)
___ 16. Encourages participative decision making in work-group sessions. (Facilitator)

Figure 3: Leadership Assessment Questionnaire, based upon the Competing Values Leadership Instrument: The View of Others[7].

From the CVF the researcher developed nodes to represent each leadership role. Utilizing NVivo, the researcher was able to code each instance of the nodes when the interviewee expressed a leadership role. Figure 4 provides an example expert of an interview code. A similar process was done for each artifact elicitation interview.

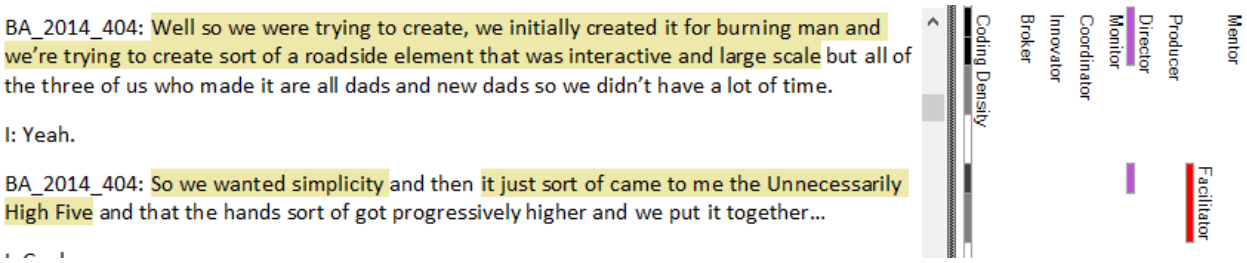

Figure 4: Example coding of an artifact elicitation interview.

Each highlighted instance of a node represents when a Maker expressed a trait like those described in Figure 3. For example, "So we wanted simplicity," represents the Maker setting a clear objective for the team, which is an example of a director role. Similarly, "it just sort of came to me," is a moment where the Maker shows the process behind consensus building, a trait of the facilitator role. After completing analysis of each individual Maker the researcher exported a matrix of each Maker's representation of each role (example matrix in Table 3). This allowed for a direct comparison of each Maker.

Table 3: Example matrix exported from NVivo.

	Brok.	Innov.	Coord.	Monit.	Direct.	Prod.	Facilit.	Ment.
Samantha	2	6	0	3	2	2	1	0
Aaron	1	1	0	2	2	2	0	0
Eric	1	2	1	3	0	0	0	0
Scott	1	1	1	0	1	1	0	0
Bradley	2	1	1	1	2	0	0	0
Stephanie	1	0	0	2	3	2	1	0
Travis	1	0	0	2	1	0	0	2

In order to map the information to a CVF profile the researcher determined what the highest representation for a node was (10 instances). Each Maker was given a rank from -3 to 3 based upon how frequently they expressed the leadership roles. The 0 mark acted as an average expression mark.

Results: Profiled Makers

For this study the 40 Makers were profiled on a leadership spectrum using the CVF. These Makers came from four flagship Maker Faires. From the collected data the frequency of responses was mapped across the CVF spectrum. The CVF utilizes scores between -3 and 3. An average of representation of the trait among Makers was taken in order to determine the 0—or average representation—mark. A minimum value (-3) shows that the Maker did not represent the leadership trait. A maximum value (3) shows that the Maker represented the highest frequency of trait representation. These minimum and maximum values were used in combination with the data matrices to determine the of leadership role representation. Table 4 provides the ranks of each Maker observed on the leadership spectrum. For the protection of the Makers' identities pseudonyms have been assigned.

Table 4: Makers' ranks on the leadership spectrum.

	Brok.	Innov.	Coord.	Monit.	Direct.	Prod.	Facilit.	Ment.
Samantha	0.5	2.3	-3	1.2	0.5	0.5	-0.5	-3
Aaron	-0.5	-0.5	-3	0.5	0.5	0.5	-3	-3
Eric	-0.5	0.5	-0.5	1.2	-3	-3	-3	-3
Scott	-0.5	-0.5	-0.5	-3	-0.5	-0.5	-3	-3
Bradley	0.5	-0.5	-0.5	-0.5	0.5	-3	-3	-3
Stephanie	-0.5	-3	-3	0.5	1.2	0.5	-0.5	-3
Travis	-0.5	-3	-3	0.5	-0.5	-3	-3	0.5
Charley	-3	-0.5	-3	1.2	2.3	-0.5	-3	-3
Nick	1.2	0.5	-3	0.5	2	-0.5	-3	-0.5
Cane	1.2	1.6	-3	2.3	0.5	-0.5	-3	-3
Matt	-3	1.6	-3	-3	2	1.2	-3	-3
Max	-0.5	-0.5	-3	2.3	2.3	-0.5	-3	-0.5
Mark	-3	1.2	-3	-0.5	2	1.6	-3	0.5
Roberto	-3	0.5	-3	-0.5	-0.5	-0.5	-3	-3
Alex	-3	0.5	-0.5	1.2	-0.5	-0.5	-3	-3
Carlos	0.5	1.6	-3	2.5	1.2	0.5	-3	-0.5
Shay	1.6	1.2	-3	1.6	-0.5	0.5	-0.5	-0.5
Julia	-0.5	0.5	-0.5	0.5	1.2	-3	-3	-3
Richard	0.5	1.6	-3	1.2	0.5	-0.5	-3	-3
Pam	-3	-3	-3	2	-3	2	-3	1.2
Ray	-3	1.6	-3	1.2	1.6	-0.5	-0.5	-3
Ruben	-0.5	2	-3	2.3	2.5	1.2	-3	-3
Stephen	2	0.5	-3	0.5	2.3	2.5	-3	-3
Rebecca	-0.5	0.5	-3	-3	0.5	0.5	-3	-3
Heather	-3	-3	-3	2	2.5	-0.5	2	1.2
Riya	-3	1.6	-3	0.5	2.5	0.5	-0.5	-3
Jason	1.6	2	-3	3	0.5	0.5	-0.5	-3
Jessica	-3	-3	-0.5	-0.5	1.2	-0.5	-3	-3
Stan	-0.5	-0.5	-3	-0.4	0.5	0.5	-0.5	-3
Yin	-0.5	-0.5	-3	0.5	2.9	-0.4	-3	-3
Jack	-0.5	0.5	-3	1.2	2.3	0.5	0.5	-3
Cindy	-0.5	-0.5	-0.5	0.5	0.5	-0.5	-3	-3
Mia	1.2	0.5	-3	1.6	0.5	0.5	-3	-3
Andrew	-0.5	-0.5	-3	1.2	1.2	-3	-3	-3
Rachel	-3	-0.5	-3	-0.5	0.5	-0.5	-3	-3
Kelsey	-0.5	-3	-3	-0.5	1.2	-3	-3	-3
Wanda	-0.5	-0.5	-3	-0.5	1.6	0.5	-3	0.5
Jenna	1.6	1.6	-0.5	1.2	2.3	1.2	-3	-3
Ronald	1.2	1.2	-3	2	0.5	-3	-3	-3
David	-3	0.5	-0.5	1.2	1.6	-3	-3	-3

Once the Makers are ranked Critical Values Framework graphs can be plotted to give a visual representation. An average of leadership ranks for each trait is taken in order to provide a representation of the observed Maker community. Figure 5 shows the resulting graph of the Maker community.

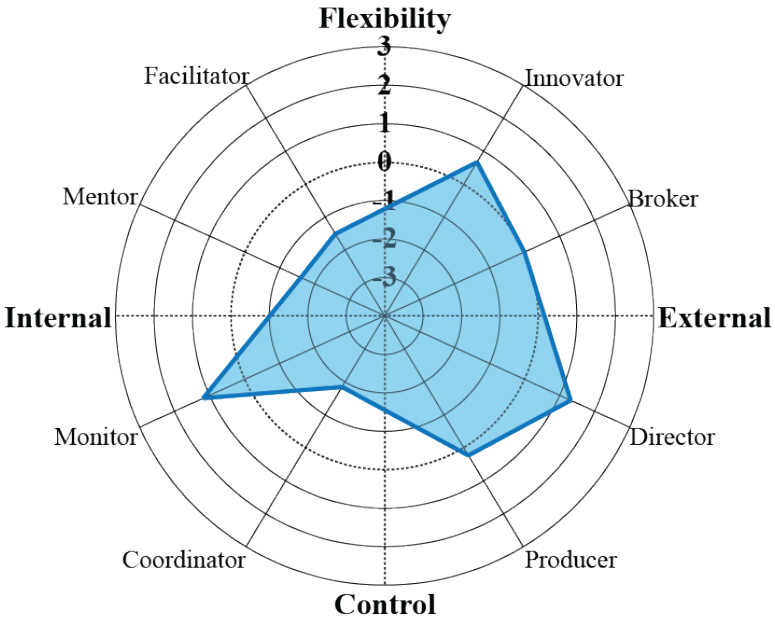

Figure 5: Profile of the Making community as derived from profiles of 40 Makers.

As can be seen in Figure 5 Makers express innovator, director, producer, and monitor leadership roles above all others. This implies that Makers hold a high aptitude in external leadership roles, while also maintaining the ability to review and analyze results. In order to see what graphs of individual Makers look like, plots were made for the top innovator, director, producer, and monitor among the observed Makers (Figures 6, 7, 8, and 9).

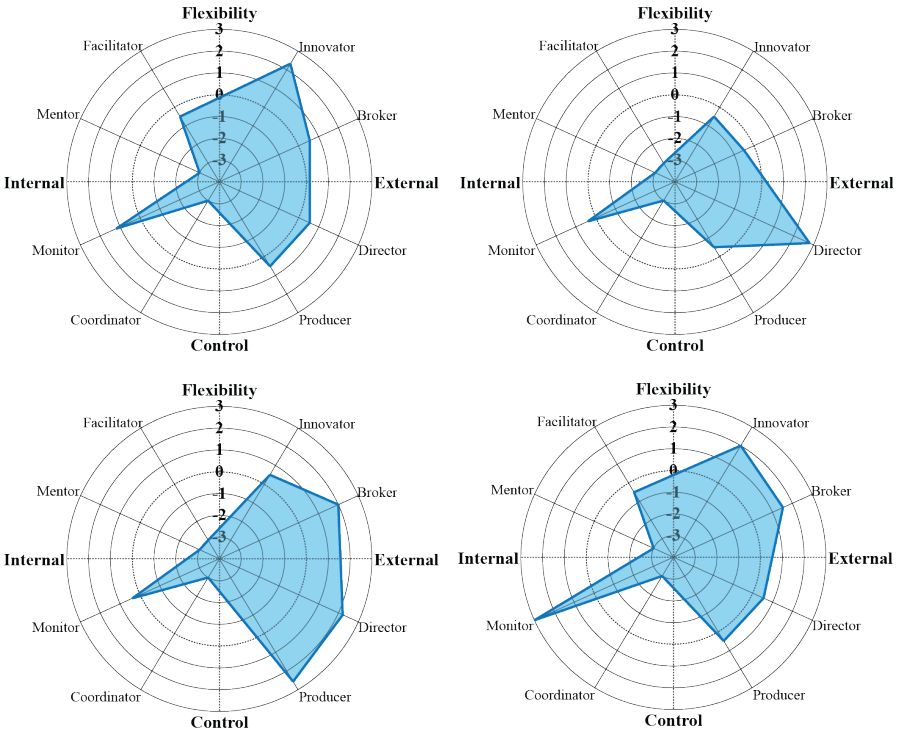

Figure 6: Profiles of the top innovator (Samantha, top-left), director (Yin, top-right), producer (Stephen, bottom-left), and monitor (Trisha, bottom-right) among the observed Makers.

From these Makers it can be observed that there is a tendency to follow the community profile in Figure 5. These Makers show relatively low in the relating to people roles and high in monitor and external roles.

Discussion: Expressions of Leadership

When evaluating the expressions of leadership within the observed Makers it was possible to note each instance a Maker expressed a leadership trait. As can be seen in Figure 5 Makers tend towards external leadership traits (innovator, broker, director, and producer) and the monitor leadership trait.

A. Innovator

Innovators are the "creative dreamer who sees the future, envisions innovations, and packages them in inviting ways"[7]. Table 5 shows the top five innovators in the observed Maker community.

Table 5: The top innovators in the observed Maker community.

	Brok.	Innov.	Coord.	Monit.	Direct.	Prod.	Facilit.	Ment.
Samantha	0.5	2.3	-3.0	1.2	0.5	0.5	-0.5	-3.0
Ruben	-0.5	2.0	-3.0	2.3	2.5	1.2	-3.0	-3.0
Trisha	1.6	2.0	-3.0	3.0	0.5	0.5	-0.5	-3.0
Jenna	1.6	1.6	-0.5	1.2	2.3	1.2	-3.0	-3.0
Matt	-3.0	1.6	-3.0	-3.0	2.0	1.2	-3.0	-3.0

As can be seen with the Makers, they tend to branch out and adapt to the situation. For Ruben, an entrepreneur with an engineering background, this involved adapting to a target customer base: "So these are like for people who are off grids." Innovators recognize problems and are looking for improvements[5]. Trisha, a leader of a start-up project from Kickstarter, noticed that existing virtual reality headsets "put a little tiny display just inches away from your eyes and that's usually very problematic; it's difficult to get it aligned correctly and it can cause headaches. Some people get dizzy and sick." Her team works around this by using projecting images out from the user utilizing augmented reality technology. By innovating Makers are able to solve problems in unique and creative ways. Samantha, a Maker with a background in electrical engineering, designed circuitry around an existing sound card and oximeter sensor to achieve the required circuit for her project. This processed utilized existing products in new ways to achieve project goals. Each Maker showed a high rank for innovative qualities.

B. Monitor

Monitors are "expected to know what is going on in the unit…to see if the unit is meeting its quotas"[7]. They are to clarify policies, expect accurate work, control projects, monitors progress, and develops measures[5]. Table 6 shows the five Makers who represented monitor traits the most among those observed.

Table 6: The top monitors in the observed Maker community.

	Brok.	Innov.	Coord.	Monit.	Direct.	Prod.	Facilit.	Ment.
Trisha	1.6	2.0	-3.0	3.0	0.5	0.5	-0.5	-3.0
Carlos	0.5	1.6	-3.0	2.5	1.2	0.5	-3.0	-0.5
Ruben	-0.5	2.0	-3.0	2.3	2.5	1.2	-3.0	-3.0
Cane	1.2	1.6	-3.0	2.3	0.5	-0.5	-3.0	-3.0
Max	-0.5	-0.5	-3.0	2.3	2.3	-0.5	-3.0	-0.5

As a monitor the leader pays attention to detail and reviews the project (Figure 3). Makers tend to reflect on the achievements of their projects. Trisha reflected upon how the new prototypes have "higher resolution graphics and a little wider field of view on the projection…and then the tracking system…is now twice as fast." Monitors also go through technical analysis and routine revision[7]. Cane, an entrepreneur in audio technology, has gone through multiple revisions of his product. In one revision Cane mentioned "the original one had a switch but people were forgetting to turn it off and it was wasting the battery." Because of this issue, Cane's group modified the device to automatically turn off and on when different devices were plugged in. A monitor must also know how to reduce information overload and focus on what the team should be doing[8]. Ruben mentions that the "design is solid" and there aren't any flaws in the artifact; therefore, the team is going to focus on adding more features as opposed to adjusting the design.

C. Director

Some Makers express the traits of a director very well. According to Quinn, a director is expected to set expectations[7, 8]. This can be done through a variety of methods, including goal setting, evaluating performance, setting roles, and defining the problem. Table 7 shows the five Makers who fit the director role the best.

Table 7: The top directors in the observed Maker community.

	Brok.	Innov.	Coord.	Monit.	Direct.	Prod.	Facilit.	Ment.
Yin	-0.5	-0.5	-3.0	0.5	2.9	-0.4	-3.0	-3.0
Ruben	-0.5	2.0	-3.0	2.3	2.5	1.2	-3.0	-3.0
Heather	-3.0	-3.0	-3.0	2.0	2.5	-0.5	2.0	1.2
Riya	-3.0	1.6	-3.0	0.5	2.5	0.5	-0.5	-3.0
Max	-0.5	-0.5	-3.0	2.3	2.3	-0.5	-3.0	-0.5

Makers interviewed are able to articulate their design process and project performances very well. As directors Makers set goals for their artifacts. Yin, a biochemical research scientist, designs jewelry with the purpose of sparking "communication and to educate" to create a "public awareness and connection with science." Directors also set roles and director projects. Heather, a student who participated in an extracurricular design program, describes how "everybody had their own unique individual parts" in a project she helped propose. Defining problems are an important part of being a director. Max, a machinist, defines the problem statement of his company as "getting machines in the hands of everyday people... [and wanting] it to be the price of a printer, something you can justify having at home." In review it becomes apparent that setting milestones and expectations is an important part of the Makers' design process.

D. Producer

Qualities of a producer include determination, focused, motivated, high energy, and having personal drive[7]. Observed Makers who fit the producer roles the most are listed in Table 8.

Table 8: The top producers in the observed Maker community.

	Brok.	Innov.	Coord.	Monit.	Direct.	Prod.	Facilit.	Ment.
Stephen	2.0	0.5	-3.0	0.5	2.3	2.5	-3.0	-3.0
Pam	-3.0	-3.0	-3.0	2.0	-3.0	2.0	-3.0	1.2
Mark	-3.0	1.2	-3.0	-0.5	2.0	1.6	-3.0	0.5
Ruben	-0.5	2.0	-3.0	2.3	2.5	1.2	-3.0	-3.0
Jenna	1.6	1.6	-0.5	1.2	2.3	1.2	-3.0	-3.0

Makers express this drive in their conviction to their projects. Stephen, an art professor who makes his own instruments, describes himself as "a person who's really interested in my world [audio and music]." Producers are going to have the motivation to focus on goals they set. Jenna, a Maker who designs her own baby clothes, aspires to "have a line of [her] own." When speaking to the Makers they often express their determination in succeeding. Ruben said he "…wanted to do something that was helpful." As producers Makers harness the determination and drive to build and succeed in their endeavors.

Discussion: Bringing Leadership to the Classroom

As a leader engineers have to be able to balance a wide range of skills. Engineers are going to need to be able to relate to people, lead change, produce results, and manage processes[5]. ABET accreditation requires a series of outcomes when educating engineers (Table 9). These leadership traits can be used to achieve desired student outcomes.

Table 9: ABET student outcomes for 2013-2014[11].

a	an ability to apply knowledge of mathematics, science, and engineering
b	an ability to design and conduct experiments, as well as to analyze and interpret data
c	an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability
d	an ability to function on multidisciplinary teams
e	an ability to identify, formulate, and solve engineering problems
f	an understanding of professional and ethical responsibility
g	an ability to communicate effectively
h	the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context
i	a recognition of the need for, and an ability to engage in life-long learning
j	a knowledge of contemporary issues
k	an ability to use the techniques, skills, and modern engineering tools necessary for engineering

With respect to the goals of ABET (Table 8) Makers fulfill a variety of student outcomes in their roles as leaders. As innovators Makers apply their design and conduct experiments (b), design within various constraints (c), and formulate ideas to solve problems (e). As monitors they analyze and interpret data (b) and identify problems (e). As directors they identify and formulate plans regarding problems (e), possess an understanding of responsibility (f), and communicate effectively (g). As producers Makers design experiments and systems (b, c) solve problems (e), possess the ability to engage in life-long learning (i), and utilize techniques and skills to accomplish goals (k).

In order to achieve these goals educators may be able to apply Making opportunities to the engineering education curriculum. This can be achieved especially through project-based learning, a teaching method suggested in *Educating Engineers: Designing for the Future of the Field*[28]. Design projects allow for students to integrate knowledge and develop skills[28]. Students operating in self-managed teams would be able to develop leadership skills through operating in various roles[5]. By taking on the typical role of "team lead" students are able to develop leadership roles as monitors and coordinators in managing processes. Operating in teams will allow students to collaborate and share knowledge and skills, similar to that of a broker. Implementing Making opportunities may allow for students to hold a similar commitment and engagement that Makers hold, inclining towards producer roles. By operating in project-based scenarios and with Making concepts students can develop the skills of setting goals and prioritizing actions, like a director. In traditional engineering education students do not have many opportunities to apply their knowledge in solving new problems[28]. By applying Making concepts students will be provided with an opportunity to innovate.

Conclusions

Given the observed data it can be determined that Makers strongly possess an external organization, and a drive to lead change and produce results. Makers fulfill the expectations of leaders as innovators, monitors, directors, and producers. Like the *Engineer of 2020,* a Maker is willing to stretch out of the traditional comfort zone as an innovator, accepting challenges beyond past roles[3]. Through their creative problem solving the mentality of Makers as innovators can "allow [for] more effective leadership in the development and application of next-generation technologies to problems of the future"[3]. As discussed Makers also fulfill a variety of ABET outcomes[11] through the expression of their leadership traits. This peek into the traits of Makers within the community allows one to see the possible benefits of incorporating Making methods into engineering education. By utilizing project-based learning students can be allowed to pursue their make.

Limitations

While this analysis strives to provide a glimpse into the Making community, every study has limitations. The research being conducted is qualitative; therefore, the existing interviews provide only a small profile of the larger population. Another caveat of the study is that the project largely consists of "research in the moment." This results in only select questions being asked, with future analysis possibilities not taken into consideration. The primary study[2] was not

specifically tailored to study leadership, however, leadership came up as a prevalent theme in the interviews. In addition, the data only shows what the participants were willing to share or able to express at the time. This analysis was done using what data was available at the time, though future endeavors could incorporate leadership traits in data collection.

Future Work

This branch of research opens up additional study possibilities. On a whole, additional Makers can be profiled on the CVF to allow for a more-fulfilled profile of the general Maker. It is realized that the study only evaluates Makers who attend flagship Maker Faires; therefore, there is some interest in studying the small-scale Maker as well. An avenue may be to interview Makers at local makerspaces or smaller events. In conjunction with a study of young Makers a longitudinal analysis can be done where young Makers are profiled on the CVF and followed-up later on in life. This study would provide an insight on how a person's time as a Maker affects the expression of leadership traits (or lack of). Additionally, a survey of engineers can be completed in order to compare expressions of leadership traits between the engineering and Making communities.

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