Important Soft Skills for Engineers to Succeed in a Work Environment

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***Abstract*—Despite research conducted on the importance of soft skills development in a work environment, there is no study that provides a method that effectively assesses soft skills development for engineers. This study will assess the perceptions of students in the Russ College of Engineering and Technology at Ohio University regarding important soft skills needed to succeed in a work environment. Conducted as part of a tool development study to measure soft skills development through mentoring using Noe's mentoring function [12] in a work environment, especially in cooperative education settings, this study will use a Q-methodology to narrow the number of statements in Kantrowitz's Soft Skills Performance Measurement (SSPM) tool [4]. Kantrowitz's SSPM extensive tool serves as a basis for the soft skills activities written out as statements used for this study. In this study, the Kantrowitz's SSPM statements are reduced from 106 to 65 statements through the first phase of the Q-methodology. Participants are asked to group similar items and name the group. The participants reduce the number of statements to 20 statements with an additional three soft skills categories suggested. For the aforementioned tool development study, these reduced statements will be used to develop soft skills performance measurement tools in an engineering cooperative education setting, together with the mentoring function scale by Noe [12].**

Keywords—Cooperative Education, Soft Skills, Work Environment, Q-methodology, Q-Sort, PQMethod, Engineering Education

I. INTRODUCTION

To understand the attributes related to hard and soft skills, many researchers have attempted to define them [1-3]. In one example, Maddocks, Dickens and Crawford [2] summarized both hard and soft skills and divided them into five categories of skills engineers need to succeed in their professional environment. These categories are:

(1) knowledge and understanding,
(2) intellectual abilities,
(3) practical skills,
(4) general transferable skills, and
(5) qualities.

In a related example, Whitmore and Fry [3], define soft skills that focused on the human element as "important job-related skills that involve little or no interaction with machines and whose application on the job is quite generalized" (p.1). These two sets of authors provide definitions of hard and soft skills that serve as a basis for the researcher's exploration of this topic.

Based on the literature, the broad definition of hard and soft skills can be summarized as follows: hard skills are teachable and usually relate to a person's ability to accomplish certain tasks, and soft skills are more difficult to teach since they are personal attributes or characteristics that affect people's ability to relate successfully to and communicate with others. In engineering, hard skills are related to the teachable attributes that serve as a foundation in developing a person's engineering competency. In industrial engineering, for example, hard skills that can be taught include employing problem solving tools or software, such as Minitab or Optimization Programming Language (OPL). In contrast, soft skills in engineering can be generalized into quality and transferable skills that cannot be taught directly, such as the ability to communicate well and work effectively in teams.

To better understand how engineering students develop soft skills, this study will rely on Kantrowitz's [4] definition of soft skills. Kantrowitz developed soft-skills performance measurement tools based on seven main soft skills clusters. The soft skills performance measurement clusters are as follows:

(1) communication/persuasion skills,
(2) performance management skills,
(3) self-management skills,
(4) interpersonal skills,
(5) leadership/organization skills,
(6) political/cultural skills, and
(7) counterproductive skills.

Kantrowitz defines counterproductive skills as behaviors that negatively impact a person's performance, such as commenting inappropriately. Her soft skills measurement tools use a constructive validation measurement of self-rated soft skills obtained from students and their supervisors during the cooperative education program. Kantrowitz also uses self-efficacy, motivational traits and personality to predict soft skills performance. In her study, results showed that self-efficacy, motivational traits and personality relate significantly to soft skills performance. She defines self-efficacy as the desire to learn, competitiveness, worry, mastery, emotionality, and other-reference goals. She defines motivational traits as how confident the participants are of acting decisively and influencing others. Personality is defined as agreeableness, conscientiousness and extroversion. For further explanation on these terms, please refer to Kantrowitz [4].

In addition to these definitions, in the Engineering Criteria 2000 (EC2000), the Accreditation Board for Engineering and Technology (ABET) lists the outcomes of the accreditation criteria as soft and hard skills. The first five criteria that are considered hard skills include the implementation of science and math skills. The last six criteria include soft skills such as engineering ethics and cross-cultural communication. These outcome-based criteria set by ABET act as the standard to craft a better engineering education.

In the past two decades, emphasis on soft skills development in engineering education has grown. In workplaces, the expectations of job performance have shifted from technical-oriented work to service-oriented work that requires employees to perform tasks while incorporating emotional intelligence as part of their soft skills [13]. Since soft skills are considered intangible assets or knowledge within a person and have been recognized as skills that are deemed important to have in a work environment, many researchers have attempted to measure those skills as a basic guideline for improvement strategies as needed.

II. Statement of Problem

This study is the genesis for a larger study that will attempt to create a soft skills measurement tool dedicated to engineers. In this study, which is based on engineering student participants' perceptions, the focus will be on identifying important soft skills that will help engineers succeed in their work environments.

The purpose of this study is to understand the perceptions of engineers concerning important soft skills that will help them thrive in a work environment. In addition, this study also aims to reduce the number of statements of Kantrowitz Soft Skills Performance Measurement (currently 106 statements) which will be used for the aforementioned engineering soft skills measurement tool development. This reduction of statements will be based on how participants perceive which soft skills are important for engineers.

III. Methodology

To understand the problem addressed in the larger study, in this study, the researcher will utilize Q-methodology as one of many mixed methods designs [14]. A mixed methods design is a procedure of collecting, analyzing and "mixing" both qualitative and quantitative data at some stage of the research process within a single study [15]. The rationale for mixing is that neither quantitative nor qualitative methods are sufficient by themselves to capture the complex and detailed situation of soft skills definitions and perceptions. The combination of qualitative and quantitative methods supports the achievement of a more complete analysis [16, 17]. This study uses Q-methodology as a *qualiquantological* method, or mixed methods approach, to identify soft skills based on the perceptions of engineers.

A. Research Design

To reduce the number of statements based on Kantrowitz Soft Skills Performance Measurement statements, the Q-sort method [11] will be utilized. This statement reduction consists of two phases: Q-sample and Q-sort. Q-sample will select 65 statements out of the 106 original statements (concourse). After participants conducted a Q-sort on the 65 statements, Q-factor analysis will then

be conducted. The five highest loading statements from each factor will be selected for use in the instrument leading to a total number of statements ranging from 15 to 25, depending on the number of factors.

B. Participants

The target population is engineering students and engineering graduates of Ohio University. The maximum number of 40 participants should be more than adequate to represent the viewpoints of a population [5-6]. The result of a Q-study normally consists of two to five groups of perspectives. For each perspective, the number of four to six individuals who have defined that particular perspective are sufficient [7]. Based on the number of items proposed (65), the sample size needed for this phase is 15 to 20 people.

C. Instrumentation

Kantrowitz's soft skills performance measurement tool, consisting of seven clusters that range from 6 to 22 items, will be used. The items are rated on two self-rating scales for students; whereas supervisors are asked to rate student's soft skills on two parallel scales. The two student scales are as follows: (1) how well they meet performance standards for each behavior and (2) how well they performed each of the behaviors in comparison to other working students. The supervisor version asks participants to rate students' performance on the following two scales: (1) how well the employee meets performance standards for each behavior and (2) how the employee's performance compares to other working students. The levels for the first scale used are: no basis for judgment (N/A); does not meet standard at all (1); partially meets standard (2); meets standard (3); exceeds standard (4); greatly exceeds standard (5).The choices for the second scale are: no basis for judgment (N/A); much worse than others (1); slightly worse than others (2); the same as others (3); slightly better than others (4); much better than others (5).

An example of an item under the political/cultural skills is "I accept feedback from my supervisor and coworkers". For communication/persuasion skill, one of the items is "I seek information to help me do my work more effectively. The intercorrelations among scales for the self-rated questionnaires for student and supervisor were large (correlations range from 0.79 to 0.97). The correlations between student and supervisor ratings were small, ranging from 0.07 to 0.21.This scale has been validated where it has demonstrated reliability (Cronbach α) above 0.70. This study will only use Kantrowitz's SSPM 106 statements without utilizing the scales and treat the statements as the concourse for the Q-methodology purpose. The scale will be used for the next phase of the study.

D. Procedures

Five steps of the Q-methodology will be conducted and include both procedures and data analysis.

Step 1: Concourse statement. This step is to develop content by writing or finding statements for the concourse of statements. For this study, the concourse of statements for soft skills comprises 106 activities of soft skills related behaviors generated by Kantrowitz [4].

Step 2: Q-Sample. The second step is developing the Q sample out of the concourse. Statements will be chosen using the structured Q sample approach, where the statements are purposefully selected based on categories or clusters. The structure is then achieved through Fisher's method [8] of experimental design. The number of statements then will be reduced to 65 items consisting of ten items for each six soft skills clusters/categories and the entire five items for the seventh cluster/category. In this phase, statements that are identified as too ambiguous are reworded or deleted if necessary.

Step 3: Q-Deck. The 65 statements are then numbered and printed in separate cards for the Q-deck.

Step 4: Q-Sort. Next, the participants will conduct the Q-sorting procedure. Participants will be asked to sort the cards into three piles: agree, neutral, and disagree. Then, the participants will sort and rank the cards from each pile. After rank-ordering the statements in each pile, participants will be asked to put the statements into a Q sort diagram based on a forced-choice condition of instruction. The instruction for the Q sort is shown in the Appendix.

The last step of the Q-methodology is the Q-factor analysis, which explained in the following data analysis section.

E. Data Analysis

Step 5: Q-factor analysis. The Q-factor analysis will then explore the soft skills factors that are important to different types of engineers. The correlation matrix from the Q sort will be used for the factor loading. A factor loading above ten percent will be considered for the analysis [9]. Varimax rotation will be utilized to distribute variance across the factor structure to ensure that each sort has the highest degree of association with only one factor by considering all factors and sorts [10]. Judgmental rotation will be utilized if necessary to ensure reliability of the factor [10]. A minimum of five participants defining each factor generate factor reliability of 0.95 [11]. Participants/Q sort associated with a particular factor will be marked with an X. The factor scores are computed using the software program, PQMethod, for the final factor solutions. Then, based on the factor analysis results, the most distinguished statements will be identified. Five statements from each category will be chosen to be included in the final questionnaire.

IV. RESULTS AND DISCUSSION

A. Participants Demographic

19 out of 20 participants were engineering students enrolled at the Russ College of Engineering and Technology at Ohio University. One participant graduated from Russ College of Engineering and Technology and spent over two years working. For the student participants, the academic level varied from junior to graduate students. The majors of the participants were:

1. Computer Science,
2. Industrial and Systems Engineering,
3. Mechanical Engineering,
4. Chemical Engineering,
5. Information and Telecommunication Systems, and
6. Civil Engineering.

The average age of the participants was 23 years old and the majority of the participants were male engineers (four are female). Eight out of 20 participated in the cooperative education program. The rest of the participants have had some work experience either as interns or graduate assistants.

B. Q-sort analysis

Based on the researcher's judgment, 65 statements from Kantrowitz's SSPM original 106 statements were chosen to be included in this study. Only statements that were ambiguous or share similarities were reworded. From the 65 statements, 10 statements represent the first six soft skills categories by Kantrowitz and the last 5 statements consist of counterproductive skills.

After participants conducted the Q-Sort process, the Q-sort analysis was performed. The Q-sort analysis is using PQMethod Software, where either centroid approach or principal component analysis and varimax rotation are utilized. For this study, PCA or the principal component analysis was used. The number of factors that resulted from the PCA approach is 8. After the factors were extracted, Varimax rotation was performed with a reduced number of factors of 5. The varimax rotation result is shown in Figure 1 below. The "x" mark is to identify participant's similarity perceptions that are loaded to certain factor loadings. For example, participant number 6 with initial SS is loaded on factor 3.

Fig. 1. Varimax rotation result

		1	2	3	4	5
1	JEL	0.42	0.37	0.17	0.22	0.59
2	CM	0.57	0.27	0.06	0.14	0.57
3	JDT	0.50	0.08	0.60 X	-0.09	0.16
4	ERM	0.38	0.29	0.08	-0.06	0.57 X
5	PB	0.21	0.36	-0.06	0.56	0.56
6	SS	-0.04	0.02	0.93 X	0.09	0.07
7	AA	0.66 X	0.31	0.01	0.34	0.34
8	BJT	0.24	0.34	0.54	0.19	0.46
9	KW	0.24	0.07	0.21	0.02	0.79 X
10	NAS	-0.02	0.85 X	-0.06	-0.10	0.03
11	EB	0.81 X	0.20	0.03	0.13	0.28
12	NAL	0.19	0.63 X	0.19	0.25	0.34
13	AK	0.57	0.41	0.25	0.30	0.25
14	SA	0.22	0.65 X	0.16	0.29	0.22
15	NVNS	0.73 X	0.00	0.13	0.13	0.41
16	NDS	0.27	0.09	0.08	0.85 X	0.08
17	SJR	0.66 X	0.05	0.10	0.05	0.40
18	TL	0.28	-0.01	0.25	0.38	0.60 X
19	PC	0.81 X	0.01	0.11	0.31	0.10
20	TR	0.45	0.33	-0.06	0.23	0.65 X

The result of the Varimax rotation led to spreading the participants perceptions on more than 3 factors loading. Then, judgmental rotation is added to the analysis to reduce the number of factors. Using the researcher's perceptions, judgmental rotation was utilized to improve the varimax rotation. The judgmental rotation performed by the researcher is shown in Figure 2 and 3 below. In Figure 3, the final result of judgmental rotation reduced the factor loadings from five to three factors with at least three participants' perception or Q-sort loaded to each factors. Table I shows the final factors with each participants loaded on each of the three factors.

Fig. 2. Judgemental Rotation

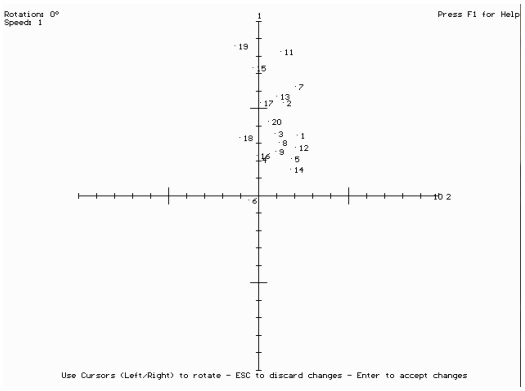

Fig. 3. Judgemental Rotation final result

	1	2	3	4	5
1 JEL	0.42	0.39	0.60 X	0.20	0.13
2 CM	0.54 X	0.29	0.50	0.23	0.26
3 JDT	0.18	0.09	0.54 X	-0.37	0.43
4 ERM	0.29	0.30	0.45 X	0.28	0.33
5 PB	0.48	0.38	0.48	0.33	-0.29
6 SS	-0.29	0.02	0.70 X	-0.54	0.02
7 AA	0.71 X	0.33	0.37	0.05	0.11
8 BJT	0.13	0.36	0.74 X	-0.08	0.09
9 KW	0.18	0.09	0.70 X	0.38	0.24
10 NAS	-0.05	0.84 X	-0.07	0.08	0.07
11 EB	0.72 X	0.22	0.30	-0.02	0.36
12 NAL	0.22	0.65 X	0.43	0.04	-0.04
13 AK	0.53 X	0.43	0.45	-0.15	0.11
14 SA	0.26	0.66 X	0.34	-0.03	-0.08
15 NVNS	0.64 X	0.02	0.46	0.03	0.34
16 NDS	0.59 X	0.11	0.34	-0.16	-0.55
17 SJR	0.56 X	0.07	0.41	0.07	0.37
18 TL	0.37	0.01	0.69 X	0.16	-0.06
19 PC	0.77 X	0.03	0.29	-0.22	0.19
20 TR	0.53	0.35	0.48	0.38	0.12

TABLE I. FACTORS LOADING

QS	1	2	3
1	0.4178	0.3911	0.5976X
2	0.5370X	0.2907	0.5005
3	0.1786	0.0932	0.5350X
4	0.2859	0.303	0.4461X
5	0.4792	0.3814	0.4816
6	-0.2903	0.0239	0.7038X
7	0.7119X	0.3334	0.3686
8	0.1328	0.3565	0.7432X
9	0.1816	0.0919	0.6999X
10	-0.0534	0.8447X	-0.0655
11	0.7250X	0.2178	0.3016
12	0.2234	0.6456X	0.4278
13	0.5310X	0.426	0.4545
14	0.2625	0.6621X	0.3426
15	0.6391X	0.0226	0.4578
16	0.5945X	0.1094	0.3431
17	0.5575X	0.0701	0.4063
18	0.3659	0.0078	0.6930X
19	0.7718X	0.0315	0.2903
20	0.531	0.3491	0.4848

Based on this judgmental rotation, there are three factors or three groups with similar points of views. Q-sort participants number 5 and 20 are not loaded to any factors due to the values that will allow them to load onto more than one factor. Based on

the result, statement number 18 "*I work as a team player and promote a team environment by cooperating with others to get the job done*" has been chosen as important soft skills behavior from the participants loaded on all of the factors. In addition to statement 18, table II shows seven statements from each factor.

TABLE II. IMPORTANT STATEMENTS FOR FACTOR 1, 2 AND 3

No.	Statement
	Factor 1
5	I seek information to help me do my work more effectively.
8	I update my skills by learning what's new in the field.
1	I show creativity and try new ideas.
24	I develop strategies and plans for carrying out work and work hard to get the job done.
30	I show a vision for where the company and the work should go.
6	I show enthusiasm for my job.
58	I solve problems quickly and effectively by taking initiative if something needs to be done.
	Factor 2
17	I am open to hearing other points of view and listen to concerns that other people have.
15	I demonstrate empathy when dealing with others and people know I am accessible and approachable.
41	I act straightforwardly and honestly when dealing with others.
46	When there are multiple opinions and tasks, I find it difficult to juggle conflicting priorities.
11	I act courteously and respectfully toward others and act patiently in a variety of situations.
48	I model the behaviors I would like to see others perform and motivate others.
32	I adjust my message depending on the audience in order to convey my point.
	Factor 3
41	I act straightforwardly and honestly with dealing with others.
58	I solve problems quickly and effectively by taking the initiative if something needs to be done.
27	I provide solutions when a problem needs to be resolved.
25	I hold my-self and others accountable for my and their actions.
17	I am open to hearing other points of view and listen to concerns that other people have.
31	I accept feedback from my supervisors and coworkers.
15	I demonstrate empathy when dealing with others and people know I am accessible and approachable.

Based on the result shown in table II, participants loaded on factor 1 have chosen the majority of the statements that are under communication skills as important skills to succeed in the work environment. Statements 1, 5, 6 and 8 are statements that are categorized under communication skills in Kantrowitz's SSPM. The participants loaded on factor 1 also deemed leadership and organization skills as important skills. These are shown when statements 24 and 30 are also chosen as one of the important soft skills, where they represent the characteristics of working hard through planning and strategizing within a clear vision.

For factor 2, the characteristics of the participants show that they deemed interpersonal skills as important soft skills. These characteristics are reflected in the statements chosen, which are 11, 15 and 17. In addition to interpersonal skills, factor loading 2 has included performance management skills, such as statement number 41, 46 and 48. Political/cultural skills are also deemed important as statement 32 is chosen as one of the important statements for participants in factor loading 2.

In factor 3, the characteristics of the participants show performance management skills and leadership/organization skills are important through statement 41. Statement 58 represents self-management skills under Kantrowitz's SSPM clustering. Statements 25 and 26 show that participants loaded on factor 3 deemed leadership and organization skills as important skills. Interpersonal

skills are represented with statements 15 and 17. Lastly, statement 31 shows that factor 3 has political/cultural skills as important soft skills to succeed in the work environment.

In addition, to the 18 statements chosen from the important statements from each factors, there are an additional two statements considered for the final survey tools based on the reasoning of the participants. Statement number 38 "I lack interest in the work that I and my coworkers do" is put in the least important category due to the negative phrasing. So, if the phrase is to be reversed to a positive statement, this will be an important statement to be included in the analysis. Statement number 57 is also a negative statement where if the statement is reversed to be a positive statement, it represents how important confidence is in one's work and abilities.

V. CONCLUSION

Based on the Q-methodology result, Kantrowitz's SSPM categories are reduced to only six. The number of statements is reduced from 106 statements to 20 statements. The six soft skills that are deemed important include communication skills, leadership skills/organization skills, performance management skills, interpersonal skills, political/cultural skills and self-management skills. In addition to those six categories, participants also suggested three additional category names. The three suggested category names are: team work skills, decision-making skills and problem-solving skills.

TABLE III. IMPORTANT STATEMENTS FOR FACTOR 1, 2 AND 3

No.	Statement
1	I show creativity and try new ideas.
5	I seek information to help me do my work more effectively.
6	I show enthusiasm for my job.
8	I update my skills by learning what's new in the field.
11	I act courteously and respectfully toward others and act patiently in a variety of situations.
15	I demonstrate empathy when dealing with others and people know I am accessible and approachable.
17	I am open to hearing other points of view and listen to concerns that other people have.
18	I work as a team player and promote a team environment by cooperativng with others to get the job done.
24	I develop strategies and plans for carrying out work and work hard to get the job done.
25	I hold my self and others accountable for my and their actions.
27	I provide solutions when a problem needs to be resolved.
30	I show a vision for where the company and the work should go.
31	I accept feedback from my supervisors and coworkers.
32	I adjust my message depending on the audience in order to convey my point.
38	I lack interest in that work that I and my coworkers do.
41	I act straightforwardly and honestly when dealing with others.
46	When there are multiple opinions and tasks, I find it difficult to juggle conflicting priorities.
48	I model the behaviors I would like to see others perform and motivate others.
57	I lack confidence in my work and abilities.
58	I solve problems quickly and effectively by taking theinitiative if something needs to be done.

Table III shows the summary of the importance statements that will be chosen for the next phase of the study. These statements will be cross-referenced with the larger study to develop a soft skills measurement tool for engineers. In addition to these important statements, distinguished statements could also be included for future research.

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APPENDIX

Soft Skills Clustering Instruction

1. Your Q-sort package should include a deck of 65 cards, a score sheet, and these instructions

2. You will need enough space to do the sorting. (Possible spaces include uncluttered tables or desk tops and, for those with cluttered desks, floors.)

3. Read through the deck of cards to familiarize yourself with the statements.

4. Next, read through the statements again, sorting them into three piles: a pile on the right for statements that you considered ***important in order to succeed in a workplace;*** a pile on the *left* for statements that you do not consider important; and a pile in the *middle* for the statements to which you are neutral or that are neither important nor unimportant. Place ambiguous or confusing statements in the middle pile.

5. Use the score sheet as a model for arranging the cards. Start with the pile on the right, select *two* statements that are the "most important" of your opinion and place them before you to represent the +5 category of the score sheet. Next, select *three* statements for the +4 category that are the next most important. Then select *five* statements for the +3 category, and so on, until you have sorted the stack of cards on the right. If you have cards left over, add them to the middle pile.

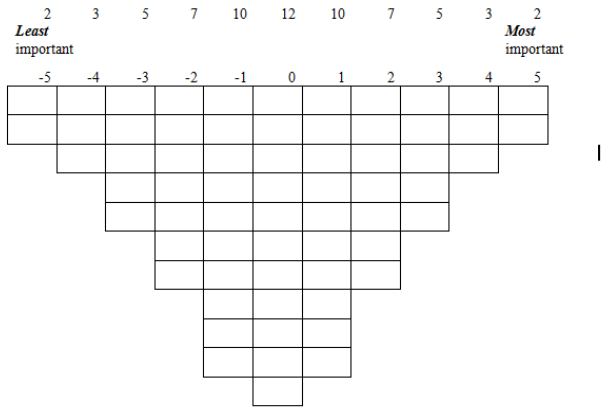
6. Next, take the pile on the left, the "unrepresentative" pile, and pick *two* statements that are "least important" of your approach and place them before you to represent the -5 category of the score sheet. Pick *three* for the -4 category, and so on, until you have sorted the stack of cards on the left.

7. Fill out the remaining blocks of the score sheet with the cards in the middle or "neutral" stack, placing those statements which are confusing or meaningless in the 0 (zero) category.

8. After you have sorted the 66 statements into the score-sheet categories (+5 to -5), look over them to see whether there are any statements you would like to re-arrange. Also be sure you have the correct number of statements in each category. Now, fill in the score sheet by writing the number of each statement in the appropriate block on the score sheet.

9. Write your reasoning for each statement you chose in category +5 and -5 on why you chose the two statements for that category.

10. Finally, write your name on the score sheet and return the score sheet and cards to the researchers.



Please make sure that each entry is ***unique*** (no double entries or skipped values).

Why did you select your **+5 choices** (most important)?