

Communication Skills Attributes For IR 4.0 For Engineering Graduates

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Abstract: *Communication skills have been highlighted as among the most important skills to be conquered by the engineering graduates. As new industrial revolution strikes in, engineering graduates are required to relearn and upgrade their generic skills to remain significant in the challenging working environment. Previous studies have identified the attributes of communication skills, but those attributes may not be relevant anymore; thus, there is a need to identify the current attributes of communication skills for IR 4.0 engineering graduates. Therefore, this study was done to derive the traits/attributes of communication skills using systematic review method considering previous studies from 2006-2019. A crosswalk of seven previous researchers was produced in this study. Emerging themes from the crosswalk are ability to effectively speak with audience; ability to convey a clear written communication; ability to communicate with people from different background; ability to deliver presentations; ability to express own idea; and ability to listen and give appropriate feedback. Findings of the study will provide a significant set of attributes in communication skills for IR 4.0 engineering graduates and embark the opportunities for further research by the authors.*

Key words : *Attributes, Communication skills, Engineering Graduates, Industrial Revolution 4.0*

1. INTRODUCTION

Communication skills are seen with an important role of preparing the young engineers for employment and career advancement. Engineers are expected to communicate well with people from diverse backgrounds, deal with multiple stakeholders, government, private organizations and the public. The importance to possess good communication skills has been highlighted in many engineering reports such as those by [1]-[4]. ABET [1] acknowledges this in their general criteria for accrediting engineering technology programs stating it as "an ability to apply written, oral and graphical communication in technical and non-technical environments; and an ability to identify and use appropriate technical literature". Meanwhile, the engineering community is faced with a high demand in regards to graduates' competencies as highlighted in

[2], “the industry is demanding that our graduates have better teamwork skills, communication abilities and an understanding of the socio-economic context in which engineering is practiced”. A recent study done by [5] has identified communication skills as one of generic skills to be pursued by young graduates to remain valuable and relevant to be hired by employers.

As new industrial revolution strikes in, engineering graduates are required to relearn and upgrade their generic skills to remain significant in the challenging working environment. WEF [6] emphasized that employers and young graduates must be ready and have an open mind to reskilling or upskilling to prevent worst case scenario when technology becomes more sophisticated, replacing the human workforce. In another study, [7] emphasized that there is a need to improve future engineers’ performance as communicators. Also, the skills related to the Architecture, Computer, Engineering and Mathematical industries are those that will be more demanding since these are the job families that are growing [8]. Additionally, future employees possess a variety of skills to be offered a job by the industries [8]-[16].

In order to achieve this, skills development of young graduates become the most important key factors for successful adoption and implementation of IR 4.0 [17]. Thus, it is important to have a clear understanding about the desired traits or attributes of communication skills that engineering students should possess with the intention to be used as a measure in the curriculum and assessment. Despite the wide availability of work done in identifying the attributes of communication skills for engineering students, those attributes may not be relevant anymore. Align with this, there is a need to classify the current attributes of communication skills for IR 4.0 engineering graduates. Hence, the purpose of this study is to identify an initial list of communication skills traits/attributes derived from existing researches’ studies from 2006-2019. In conducting this study, a systematic review was used as its methodology. A crosswalk of previous studies was conducted to identify the emerging themes of communication skills attributes. The findings from this study will allow for further researches by the authors.

2. LITERATURE REVIEW

2.1 Definition of Communication Skills

As defined by [18], communication begins when the sender (speaker, writer) is transmitting a message or information by means of a medium or instrument to the receiver and followed by the recipient, who offers input by codifying and analyzing the input. Meanwhile, communication is defined by [19] as a relational relationship that describes exchanging and giving meaning simultaneously. In addition, [20] added that to other scholars, communication is described as verbal, written, nonverbal, audible and providing feedback. Rodiah [21] further suggests communicating as a non-verbal ability that offers feedback, verbal and written proposals, ability to conduct presentations and negotiate to obtain an aim and gain assistance/understanding. In addition to creating technologically appropriate designs by the current engineers, [22] pointed out that they should also transmit these designs in the form of writing, oral and graphic to a range of audiences varying from the academic peers to the general public. According to [23], however, communication primarily includes the sharing of ideas, thoughts and data with a particular goal. In general terms, it is described as a process of knowledge exchange from an individual to the person who receives it through oral and non-verbal methods. The most popular communication form is verbal, with responses obtained

on the message utilizing a particular language where it is a two-way mechanism. Details can often be shared with symbols or signs in addition to oral contact. This research is aimed at providing a summary of the characteristics and attributes of communication skills particularly for graduates of engineering. The authors therefore did not plan to create a new term, but rather used the current definitions of [23] on communication skills.

2.2 Review of Past Studies

In order to understand the application, importance and challenges of implementing communication skills among engineers, the first thing to consider is to first identify the features or attributes of effective engineering communication skills. There are several features of engineering communication skills identified through the literature based on studies done by previous researchers (Table 1).

Table 1: Previous studies on attributes of communication skills from 2006-2019

Year	Author
2006	Ministry of Higher Education (MOHE)[24]
2009	Azami Zaharim et al. [25]
2010	Nicometo et al. [26]
2015	Ahmad Tajuddin Azza Jauhar[27]
	Zaliza Hanapi[28]
2018	Wisniewski Elaine [29]

2.2.1 MOHE (2006)

2019	Lilian Maria de Souza Almeida [7]
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Reference [24] has listed communication skill as one of the seven skills that need to be mastered by IPTA graduates. Each stated skill has certain attributes that need to be achieved by students to be considered competent in terms of their soft skills or generic skills. However, KPTM only emphasizes on some of the key skills and attributes that are labelled as Must Have Soft Skills (KIM). The three attributes of KIM's communication skills are the ability to convey ideas clearly, effectively and confidently, in verbal and writing; the ability to practice active listening skills and provide feedback; and the ability to conduct presentation clearly with confident and appropriate to the level of the audience. Meanwhile, the additional attributes that will provide additional value to students are known as Good to Have Soft Skills (KIT). If students are able to master these additional attributes, it is considered as an added bonus that increases the chances for job employment. The attributes of KIT communication skills are the ability to use technology in presentation; ability to negotiate and reach agreement; ability to communicate with participants of different cultural backgrounds; ability to develop individual communication skills; and the ability to use non-verbal skills. In this study, the researchers took into account eight types of communication skills' attributes identified as benchmarks for comparison and mapping to other studies. Table 2 shows the list of the attribute of communication skills obtained from [24].

Table 2: List of communication skills attributes from MOHE

Skills	Descriptions
KIM	Ability to present information and express ideas clearly and effectively through written and oral modes
KIM	Ability to actively listen and respond to the ideas of other people
KIM	Ability to make clear presentation confidently and appropriate to audience
	Ability to use technology in presentation
	Ability to negotiate and reach agreement
	Ability to communicate with people of different culture
	Ability to develop communication skills individually
	Ability to use non oral skills

2.2.1 Azami Zaharim et al. (2009)

Reference [25] proposed a Malaysian Engineering Employability Skills (MEES) as a guideline to instill generic and technical skills needed for engineering graduates to be ready for industry practice locally and internationally. The system was built based on existing studies on the issues in engineering related to employability skills and the requirement for engineering program accreditation. MEES follows the specifications and meets the guidelines of the Accreditation Board for Engineering and Technology (ABET), the Engineering Accreditation Councils of Malaysia, the Board of Engineers Malaysia (BEM) and the Malaysian Quality Assurance (MQA), Department of the Ministry of Higher Education Malaysia, Washington Accord 1989, and also satisfies qualification criteria of other professional bodies. One of the generic skills stated in MEES is communication skills and the list of attributes is shown in Table 3.

Table 3: List of communication skills attributes in MEES

Skill	Description	Attributes
Communication skills	Ability to present ideas with confident and effective through aural, oral and written modes, not only with engineers	Speak in clear sentences
		Give clear direction
		Listen and ask question
		Ideas presented with confident and effective
		Speak and understand more

	but also with the community at large	than one language
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2.2.3 Nicometo et al (2010)

A study done by was to identify the attributes of effective communication skills from the industry’s perspective. The National Science Foundation was responsible for the funding of the research, which explores, in part, how well- or under- prepared engineering students are to succeed in this field by aligning the engineering practice and preparation. Mixed-method study was used in the study conducted in two phases known as qualitative study phase and quantitative study phase through qualitative data collected over the past two years in six workplace case studies (including over 50 hours of observation and more than 50 interviews) and interviews of 91 engineers and their managers. The interviews were performed using a questionnaire composed of 15 open-ended questions asking the respondents on their background, why they wanted to be an engineer as well as their job goals. All data collected were managed and coded using the NVivo software package. Meanwhile, in quantitative phase, an electronic survey was sent to 264 alumni of the college of engineering in one of midwestern public universities. Three main themes emerged to provide insights into what engineers mean when they say they value “effective communication” in other engineers. The first theme was what numerous engineers in our study described as “the big picture,” or the ability to effectively speak, write, and interact with audiences who were outside of their specific discipline, work group or focus. In consequence, second theme centered on an engineer’s willingness and self-motivation to initiate communication with others and to seek out resource information through informal interactions. Finally, the third theme involved the ability of engineers to listen carefully to others to do their best work and achieve results that are valued by their stakeholders (clients, managers, co-workers).

2.2.4 Zaliza Hanapi (2015)

Reference [28] in her study has identified the key elements of technical skills and employability skills that need to be mastered by electrical engineering graduates at one of community college in Malaysia using a modified Delphi method by seven electrical specialists. In addition, the key elements of technical skills and employability skills were identified through analysis documents and references of previous studies. Overall, through interviews conducted on a panel of Delphi experts in the first round, eight key elements of employability skills were identified namely communication skills, creative and critical thinking skills, information management skills, teamwork and cooperative skills, self-management skills, professional ethical and moral skills, leadership skills and entrepreneurial skills. Next, validation factor analysis was used to validate the elements or attributes of the communication skills obtained from the three-stage Delphi method. The list of attributes obtained in this study is shown in Table 4.

Table 4: Attributes of communication skills

Skill	Attributes
Communication skill	Ability to read work manuals, graphs, charts or tables
	Ability to understand work

	manuals, graphs, charts or tables
	Ability to read, understand and write short notes, memos or letters in a comprehensible way
	Ability to read information in English
	Ability to compose and write work reports clearly
	Ability to compose and write work reports in English
	Ability to formulate what an individual or group says
	Ability to write statements or sentences logically and comprehensively
	Ability to fill out a job-related form quickly
	Speak fluently and clearly with individuals or groups such as that in presentations
	Ability to express opinions and information verbally and clearly
	Ability to speak fluently with body language such as eye contact, postures and gestures
	Speaks fluently and clearly in English

2.2.5 Ahmad Tajuddin Azza Jauhar (2015)

A study done by [27] has explored the actual professional communication skills (PCS) needed to be taught in higher education institutions of Malaysia. Additionally, the study aimed to produce an informed, impartial and highly valid PCS framework for English by having the stakeholders. By using qualitative method, data were collected from in-depth interviews with 24 respondents in the following subgroups, which were, i) 10 informants from human resource managers from key multi-national industries; ii) 4 informants' government executives who recruit entry-level employees for public sector and; iii) 10 informants from EOP instructors and higher education liaison officers for industrial training. The interview was transcribed and analyzed using ATLAS.ti 7.0 software Reference [33] identified four skills categories based from literature review and conversations from youth focus groups. Focus groups were conducted with members of the Global Business Coalition for Education Skills and Innovation Initiative Youth Advisory Council. Nine youths attended four focus groups; the participants were aged between 19 and 29 from several countries including Jordan, Nigeria, Singapore and the United States. Focus groups lasted about 60 minutes. Table 5 displays the skills identified from the data analysis.

Table 5: Professional communication skills

Skills	Description	Attributes
Interpersonal	Contribute to	Speak

communication	diplomatic and matured communication between superior, subordinates and clients.	comfortably with employers, not hindered with nerves
		Pay attention to workplace communications activities and do not get distracted easily (with electronic devises)
		Attentive in formal or informal workplace communication which can help build rapport with superiors, colleagues and clients
		Well prepared prior to workplace meetings and planned activities in order to express opinions maturely.
Listening skill	Contribute to successful working	Ask if one does not understand instruction by

	relationship and effective execution of tasks	superior, colleagues, and
		Disagree politely if better ideas can be brought up during meetings and negotiation.
		Respond appropriately (speech or non-verbal communication) after understanding the instructions, questions, etc. from superior, colleague
		Fully comprehend what is going on around them at workplace.
		Give feedback when asked by colleagues, superior and clients after fully understanding the situation
		Responds to clients' complaints
		Understanding others during briefings, seminars, conferences and presentations.

Presentation skill	Contribute to sharing of ideas and thoughts effectively with superior, colleagues and clients	Able to share ideas with colleagues creatively
		Able to persuade clients to accept their ideas by explaining in a simple yet interesting manner
		Inform superiors of new innovative measures in improving workplace.
		Keep spectator's attentions using range of presentation skill, with the help of IT as a management tool.
		Responding to

		to accept ideas and opinions using well-defined explanations.
		Use specialist vocabulary in a correct manner
		Give clear instructions to solve issues at work
		Initiating contact, requesting information on the telephone.
		Seeking information from others at work
		Responding to enquiries/problems from superior/clients
		State reasons for disagreeing without interrupting the speech of colleagues or superiors
		Discussion work schedules and procedures.
		Engage small talks with superior, colleagues and clients informally
		Telephone conversations skill – answering inquiries, giving instructions.
Nonverbal communication	Contribute to the ease and comfort during interactions.	Appropriately dressed according to workplace occasions.
		Be on time in all workplace functions

		Control own nerves in meetings with superior and clients in order to be less agitated.
		Ensure their body language is not offensive during conversations with colleagues, superiors and clients.

		Wear pleasant facial expression.
Writing skill	Contribute to effective execution of tasks at work and making the work flow efficient	Filling in forms.
		Write memo.
		Write formal business letter
		Write minutes of meeting
		Write a summary of articles
		Write for the company's website
		Write formal/informal email messages
		Write items for newsletter
		Write reports using office template.

2.2.6 Wisniewski Elaine (2018)

Reference [29] in her study identified workplace communication practices of novice engineers and the perceptions of their managers. Mixed-methods case study was employed to identify common themes. Qualitative data were collected through open-form survey questions, diary/activity logs with follow-up semi structured interviews and contextual inquiry methods. Next, quantitative data were collected through surveys with Likert-rating scales and choice questions. Data were collected using three sources from novice engineer, engineering manager and researcher. Three themes were derived from data analysis for communication skills abilities. The themes were :

- a) ability to interact with varied audiences (upstream, midstream, downstream, external) by addressing audience needs and using audience preferred medium (memo, reports, e-mail, text, phone, face-to-face, visuals).

- b) ability to apply communication strategies by using appropriate structure and message focus, using clarity, concision, and a professional tone.
- c) ability to apply interpersonal skills by delivering information confidently and working as a team.

2.2.7 Lilian Maria de Souza Almeida (2019)

In another study, [7] has explored the characteristics of communication skills required for engineers from four industrial sectors with the belief that modern curriculum will be tailored closely to the needs of employers. A qualitative approach was employed in the study to provide a detailed description of the communication skills practicing engineers need while working in industry. The case studies were chosen from four industrial segments (High-Tech, Automotive, Aerospace and Manufacturing) representing a large percentage of engineers in the U.S. The results revealed that: 1) oral communication is prevalent in the engineering profession; 2) engineers need to tailor their messages to multiple audiences and select the most appropriate type of communication medium; 3) written communication is expected to be clear, concise and precise; 4) global communication is an increasingly demanded requirement in industry.

Table 6: Communication skills expected from practicing engineers in industry

Theme	Description
Oral communication	Ability to explaining ideas and answering questions, using simple and direct communication, eliminating ambiguities, using different tones depending on the situation, and focusing on the important points of the message.
	Ability to convince other people about their ideas and by clearly translating their messages into appropriate and understandable content.
	Ability to tailor the message accordingly are important requirements for engineers to communicate successfully.
	Able to select appropriate communication channels to get the message across
	Able to communicate in an increasingly global workplace and interact effectively with different international audiences.
	Ability to communicate cross-culturally successfully

Written communication	Ability to write a clear, concise, and precise free from grammar errors and misspellings.
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3. METHODOLOGY

Based from anecdotal evidence in the literature search, the attributes of communication skills were derived by conducting a meta-analysis on the available studies in literature search. This section further discusses the communication skills studies that have been identified from a systematic literature review (SLR). A detailed explanation on the systematic literature review used in this study can be referred to a study on identifying emotional intelligence attributes by [30] and comparison of existing skills by [13]. A list of the aforementioned previous studies is shown in Table 1.

4. CROSSWALK OF COMMUNICATION SKILLS ATTRIBUTES

In this section, a crosswalk based from seven existing studies was done. Based on this mapping, this study has derived six attributes for communication skills as shown in Table 7. The six attributes of communication skills are ability to effectively speak with audience, ability to convey a clear written communication, ability to communicate with people from different background, ability to deliver presentations, ability to express own idea and ability to listen and give appropriate feedback.

According to Table 7, the first attribute mentioned by each researcher is the ability to effectively speak with audience. This attribute emphasizes the importance of communicating well with other people. As engineers, they are expected to speak clearly as an individual, able to right order to others and answer questions using simple and direct communication. As cited from [7], oral discourse must rely on the fundamental points of the message, clear and concise enough to offer suggestions and responses, prevent potential misunderstandings and use various tones of a circumstance. In comparison, face-to-face contacts are more common than oral conversations including phone and conference calls. According to [31], engineers spend more time (about 690 hours per year) communicating information output and ideas orally than in written forms. The information outputs take in many forms from consultation to giving presentations.

The second attribute derived from the crosswalk is the ability to convey a clear written communication. This attribute relates to the ability to write report effectively and write clear report when asked. Writing will be used for work applications, communicating with co-workers and good writing makes it easier to get through with opinions. Ineffective and poor written communication in engineering workplaces has been found to lead to misinterpretation, inefficiency and time wastage, thereby adversely affecting problem resolution. According to [7], there are many types of documents written in the engineering profession, including engineering requirements, technical specifications, design documents, manufacturing documents, work instructions, test reports, analysis reports, status reports, presentations and all types of e-mails. Unfortunately, findings from [32] found that students typically feel that writing is important, but they do not understand how it is used in their future career. Thus, it is important to include instances of various forms of professional communication to help students in attaining the communication education offered.

The next attribute of communication skills is the ability to communicate with people from different background. In this regard, engineers are expected to be able to work and communicate with different stakeholders, seek out resources of informal or other people, contribute to sharing of ideas and thoughts effectively with superior, colleagues and clients and able to communicate cross-culturally and with varied audiences.

Table 7: Crosswalk of communication skills attributes

A [24]	B [25]	C [26]	D [27]	E [28]	F [29]	G [7]	Derived attributes from crosswalk
Able to speak clearly	Able to give right order to others	The ability to effectively speak, write, and interact with audiences outside of engineers' specific discipline, work group, or focus	Contribute to productive and appropriate verbal interactions at workplace	Able to speak clearly as an individual	Ability to apply interpersonal skills by delivering information confidentially	Answering questions using simple and direct communication Able to convey a clear, concise and precise written communication	Attribute 1 Ability to effectively speak with audience
Write clear report when asked	-			Able to write report effectively and clear			Attribute 2 Ability to convey a clear written communication
Can communicate with others	Can work and communicate with different stakeholders	Seek out resources of informal or other people	Contribute to sharing of ideas and thoughts effectively with superior, colleagues and clients	-	Ability to interact with varied audiences	Able to communicate crossculturally	Attribute 3 Ability to communicate with people from different background
Do a good presentation	-	-	Do good presentation in working field	Able to deliver presentation in groups	Ability to apply communication strategies by using appropriate structure	-	Attribute 4 Ability to deliver presentations
-	Confident	Give idea	-	Able to	-	Explaining	

	tly deliver own idea	and accept critic		present own idea		ideas using simple and direct communication	Attribute 5 Ability to express own idea
Able to hear actively during conversation	Able to listen and ask questions	The ability to listen carefully to other	-	-	-	Listen patience and give feedback	Attribute 6 Ability to listen and give appropriate feedback

Remarks : A-MOHE (2006); B- Azami Zaharim et al. (2009); C-Nicometo et al. (2010); D-Ahmad Tajuddin Azza Jauhar (2015); E-Zaliza Hanapi (2015); F- Wisniewski Elaine (2018); F- Lilian Maria de Souza Almeida (2019)

Meanwhile, the fourth attribute derived is the ability to deliver to deliver presentations. Presentations, in particular, take place either internally, externally, in small group settings or in formal settings. In small group settings, engineers are engaged in informal work-related discussions with colleagues, staff and seniors, whereas in formal settings, they give presentations related to researches, proposals, projects and other works in meetings, conferences and seminars [33].

The fifth attribute of communication skills is the ability to express own idea. Based on the mapping, an engineer with good communication skills should be able to deliver his or her own idea with confidence, willingness to accept critics and explain ideas using simple and direct communication. According to [33], engineers should learn adequate new vocabularies, which enrich their oral and written speech with various vocabulary content specific to their area of study by enabling them to increase the total length and suitability of responses.

Finally, the six attribute of communication skills is the ability to listen and give appropriate feedback. This attribute emphasizes on the ability to listen actively and patiently during conversation, also give appropriate feedback by asking relevant questions or answers. Kline [34] affirmed that listening is crucial in the workplace across the professions, including engineering. Listening involves the interpretation and clear comprehension of spoken communication and the spoken meaning may be misunderstood or missed without the proper listening skills, allowing the communication mechanism to collapse. Work-based practices offer a solid background for the training of an engineer. These listening skill exercises may be incorporated in a research setting and aid students in team activity, a more essential engineering task.

5. CONCLUSION

This study was done to identify the communication skills attributes for IR 4.0 graduates. Using a systematic literature review, five attributes of communication skills that are common across seven existing studies have been identified: ability to effectively speak with audience; ability to convey a clear written communication; ability to communicate with people from different background; ability to deliver presentations; ability to express own idea and the ability to listen and give appropriate feedback. The results from this research were not proposed as the ultimate solution, but for other related researchers, they are useful and vital as a fundamental insight into

developing communication skills especially for future engineers. Further study should be carried out to verify the outcomes that can be utilized by researchers to create an IR 4.0 skills framework for graduates in engineering.

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