

## Exploration and verification of fourth industrial revolution generic skills attributes for entry-level civil engineers

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### ABSTRACT

The fourth industrial revolution (4IR) requires the workforce to be equipped with new skills when existing skills need to be upgraded or improved because they are no longer in line with technological advancement in 4IR. Thus, it is crucial to determine what the new skills or 4IR skills are that can help the future workforce obtain a job after graduation. This study aimed to explore and verify the attributes of nine 4IR generic skills (GS4IR) for entry-level civil engineers in Malaysia by using a qualitative approach. An interview session was conducted with five senior engineers in the civil engineering (CE) field and three experts (two engineers in CE and one lecturer in CE faculty) for reliability data verification. The interview data were analyzed using coding analysis and presented in a matrix table. The results show 76 items identified as attributes of nine GS4IR constructs. Next, the verification of the constructs and attributes of GS4IR was obtained from Fleiss Kappa's reliability analysis to determine the overall approval index. The results of the analysis revealed an overall Kappa coefficient value of 0.61, which indicates a good level of agreement. The findings of this study consist of 58 attributes for nine constructs of GS4IR approved after the inter-rater reliability among the experts. The findings from this study are beneficial for the development of a framework of 4IR generic skills for civil engineering graduates as guidance to instill new skills in producing future engineers.

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## 1. INTRODUCTION

The wave of the fourth industrial revolution (4IR) is accompanied by the use of robotics and the automation of changes to the demand for labor and the field of employment. The report from World Economic Forum [1] stressed that 4IR will cause a paradigm shift in various aspects such as employment, skills, and staffing regardless of other types of industry sectors. In the context of Malaysia, the government estimates that 1.5 million new jobs will be created, which will require 60% of skilled workers by 2020 [2].

Accelerated change like work in the past few decades has engendered great debate from industry, government, and employees themselves. One focus of the debate is the future of work and employment and the kinds of skills required to maintain competitive economic productivity [3]–[5]. The 4IR affects the curriculum in the education system, whereby only qualified and highly skilled employees can control the new

technologies [6]. Not only are existing and skilled jobs required in the academic field, but there are also generic skills that meet the needs of employers. Every individual needs to upgrade or develop a set of skills that will make them able to work in a 4IR setting [7]. In another study [8], skills have changed according to the changes in the era of industry revolution 4.0, although certain skills remain unchanged and need to be enhanced to complement the needs of today's industry. Meanwhile, new skill sets will be required to be created to perform existing and new jobs that will emerge owing to industry 4.0 technological advances [1], [9]. Accordingly, only a workforce with relevant skills and qualifications will survive and become successful in a highly innovative industry.

To meet the challenges of 4IR, the government has made plans and actions to help graduates be equipped with the new skills required by the industry. Malaysia is one of the earliest countries to formulate the 4IR elements in the Malaysian Education Blueprint (Higher Education) 2015-2025 [10]. In 2015, the Ministry of Education Malaysia [10] outlines 10 leaps; among them, producing holistic graduates who can move from a search environment to job creation using skills applied by institutions of higher learning.

According to the UK Commission for Employment and Skills [11], 43% of job vacancies in engineering and technology are due to a lack of generic skills required by employers. In 2016, UKCES [11] also highlighted that over 35% of the skills that are relevant in the contemporary workforce will become obsolete in the next five years. In another report, the engineering profession and government need a major shift in their collective commitment to supporting lifelong learning and professional development to ensure workers continue to develop new skills in an increasingly technology-driven world [12]. By 2020, the 4IR is already introducing us to autonomous transport, advanced robotics, advanced materials, artificial intelligence (AI), machine learning, and biotechnology. All these innovations will transform our way of living and the way we do our jobs, as some existing jobs will disappear with the emergence of new ones that do not exist today. The demand will be for the emerging workforce to align their skill sets to keep pace. This suggests that the problems facing the world of work in the future are not due to job supply factors but to a lack of understanding of 4IR generic skills in line with industry needs and demands.

The issue with developing suitable skills that align with the industrial revolution is that it takes a longer period, just like the industrial revolution before. From one industrial revolution to the next, some jobs disappeared, while others were created. More importantly, some skills become redundant while others become valuable. The upcoming fourth industrial revolution is no exception to the replacement of jobs and skills. More importantly, some skills turn out to be superfluous. In contrast, others become valuable in engineering firms. The problem lies in the fact that industry 4.0 has the potential to increase unemployment through the use of automation unless the subject of skilling and re-skilling for the digital economy is addressed from the onset by enhancing skills development in academic institutions.

A research identified nine 4IR generic skill constructs for entry-level civil engineers [13]. The 4IR generic skill constructs are: i) Communication skills; ii) Problem-solving skills; iii) Leadership skills; iv) Emotional intelligence skills; v) Creativity skills; vi) Critical thinking skills; vii) Adaptability skills; viii) Digital skills; and ix) Management skills. However, there is still no explicit specification on the attribute requirements [14] that are specific to the work field [15], [16] which has become the primary cause of graduate unemployment. Thus, this study was conducted to explore the attributes of nine 4IR generic skills (GS4IR) for entry-level civil engineers based on the opinions of experts in the civil engineering (CE) field. Afterward, attribute verification was conducted to confirm the findings of the qualitative data.

## **2. RESEARCH METHOD**

### **2.1. Research design**

This study used a qualitative method. In exploring the 4IR generic skill attributes, the method of interviews with experts in the field of civil engineering was used. In this study, a semi-structured interview method was employed. Semi-structured interviews are an effective method for data collection when the researcher wants to: i) Collect qualitative, open-ended data; ii) Explore participant thoughts, feelings, and beliefs about a particular topic; and iii) Delve deeply into personal and sometimes sensitive issues [17]. The selected data was given to three experts in the civil engineering field to review and commend. This process was done to get the interrater reliability of the construct using the Fleiss Kappa reliability analysis ( $K_f$ ). The  $K_f$  value will be used to determine the degree of agreement between the findings.

### **2.2. Participants**

Expert sampling was used to identify informants for this study. This sampling technique is generally used to obtain input from the most knowledgeable and experienced samples regarding the subject matter under study [18]. In selecting the right informants, they must meet the following criteria: Senior organizational positions (Senior Engineer/Manager/Director/Chief Executive/Chairman). According to

Yuzainee [19], this criterion is important because they are the people who have experience in recruiting entry-level engineers for the company. The informants must have working experience in the CE field for at least 3 years. By referring to the report [20], after 3 years, an engineer is allowed to pursue the status of a professional engineer (Ir.) because they have been exposed to experience and knowledge, making them the right informants to be selected in the study.

Table 1 shows the list of expert panels selected based on expert sampling for the qualitative study. In exploring the 4IR generic skill attributes, five experts in the CE field were selected. The first informant (I1) is a contractor with 12 years of working experience. Informant 2 (I2) is a civil engineer from the Public Workers District (PWD) specializing in the Geotechnics area with 19 years of working experience. Informant 3 (I3) is also a civil engineer from PWD with 18 years of working experience in Road and Highways Engineering. Informants 4 (I4) and 5 (I5) were from Government-Linked Companies (GLC) with 13 years of working experience, respectively. Meanwhile, three experts were selected to verify the 4IR generic skill attributes, which are: i) Manager for the construction industry with 10 years of working experience; ii) Civil engineer from PWD with 20 years of working experience in Roads and Highways Engineering; and iii) Senior lecturer from civil engineering faculty with two years of working experience in the industry and 14 years as an academic.

Table 1. Expert sampling for the study

Phase	Informant/Expert	Position	Work experience
Exploration of 4IR generic skill attributes	Interview with an expert	I1	Contractor
		I2	Civil Engineer G52 (PWD)
		I3	Civil Engineer J48 (PWD)
		I4	Senior Engineer (GLC)
		I5	Senior Engineer (GLC)
Verifying 4IR generic skill attributes	Content validation	A	Manager (Industry)
		B	Civil Engineer J48 (PWD)
		C	Senior Lecturer (Civil Engineering)
			12 years
			19 years
			18 years
			13 years
			13 years
			10 years
			20 years
			Industry – 2 years Education – 14 years

2.3. Instrument

For analyzing data, a coding system was utilized to facilitate the process of identifying data types and research questions [21]. Researchers have adapted the coding system method used by Husain [22]. An example of the code system used by the researcher is shown in Figure 1.

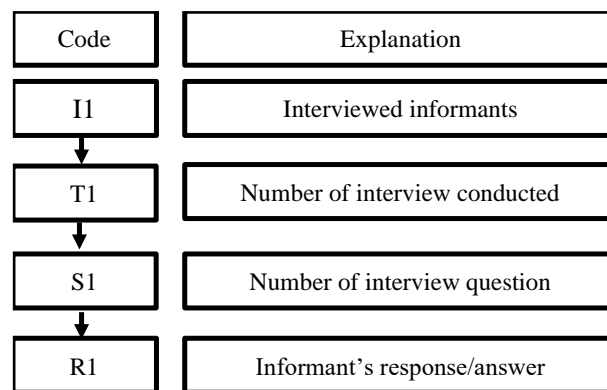


Figure 1. Coding system

Based on Figure 1, an example of the code system mentioned in this study was I1T1-S1R1, where I1 represents the first informant interviewed, T1 represents the number of interview sessions conducted, S1 is the question number, and R1 is the response to the question asked during the interview session. Five informants coded I1 to I5 were engaged in an interview session to explore attributes appropriate to the 4IR generic skill constructs. Next, a matrix analysis was conducted to facilitate the comparison process and extract the theme of the 4IR generic skill attributes. This method was used according to the views of the researcher. This is supported by [23], where analysis is performed depending on the researcher's creativity.

Once the constructs and attributes of 4IR generic skills were identified, experts' consent was obtained to validate the findings from the qualitative study. The validation process was carried out through the analysis of the Fleiss Kappa consent index by appointing three experts in the field of civil engineering. This analysis aims to find the degree of agreement between the unit of analysis (attribute) and the study construct. This was done by matching units (attributes) from the interview data with 4IR generic skill constructs. To obtain the value of the coefficient of agreement between experts, the Fleiss Kappa formula is used, as in (1).

$$K_f = \frac{P_a - P_r}{1 - P_r} \quad (1)$$

Where,  $P_a$  - rating approval level based on observations;  $P_r$  - the probability of consent hypothesis by chance, using observational data to calculate the probability of each observer at random in each category.

According to Mishra and Nitika [24], if the value  $\kappa$  approaches value 1, this means that the assessor has reached an agreement among the assessors. Whereas if the value  $\kappa$  approached 0, it means there was no agreement between the assessors. Based on Table 2, the scale value of the Kappa coefficient of consent  $K_f$  value is shown to see the value of reliability [25].

Table 2. The value of the Fleiss Kappa coefficient

Kappa value ( $K_f$ )	Level of agreement
$K_f < 0.00$	Very weak
$0.00 < K_f < 0.20$	Weak
$0.21 < K_f < 0.40$	Moderately weak
$0.41 < K_f < 0.60$	Moderate
$0.61 < K_f < 0.80$	Good
$0.81 < K_f < 1.00$	Very good

### 3. RESULTS AND DISCUSSION

Based on the interview with experts, 76 attributes were obtained for nine constructs of 4IR generic skills for civil engineering graduates. These nine generic skills need to be instilled in graduates to ensure that graduates can be accepted to work after graduation [8], [26]. Next, the results from the interview were verified to ensure their validity and reliability. For the first construct, communication skills are defined as the ability to transmit and receive information clearly and include the ability to read the audience to avoid and resolve conflicts. Referring to the results of the agreement from three experts, all the attributes were in 100% agreement, which indicates that these attributes are suitable to represent the communication skills needed by the CE industry. Entry-level civil engineers can acquire good communication skills by acquiring all the attributes of communication skills. Table 3 shows the results for verification by the experts.

Subsequently, Table 4 shows that all the attributes of problem-solving skills show the value of the agreement is 1.00, which means the assessor has reached the consent of the assessors. Graduates in civil engineering are expected to equip themselves with all the agreed attributes to be hired as entry-level civil engineers in the 4IR working environment.

Table 3. Expert's agreement for communication skill construct

Attributes	Raters			% Agreement
	A	B	C	
Ability to communicate efficiently	1	1	1	1.00
Ability to convey messages through written communication	1	1	1	1.00
Ability to do the presentation in front of clients	1	1	1	1.00
Ability to communicate with people at all levels to achieve certain goals	1	1	1	1.00
Ability to speak fluently in English	1	1	1	1.00
Ability to choose a suitable medium or technology to communicate with others	1	1	1	1.00

Table 4. Expert's agreement for problem-solving skill construct

Attributes	Raters			% Agreement
	A	B	C	
Ability to affirm a problem	1	1	1	1.00
Ability to think of a variety of tactics and heuristics to tackle problems	1	1	1	1.00
Ability to ask a question to an expert or mentor	1	1	1	1.00
Ability to use experience or knowledge in making a judgment	1	1	1	1.00
Ability to review and reflect on the effectiveness of own's problem solving	1	1	1	1.00

Table 5 reveals that two attributes, namely: the ability to take the risk of an action/decision and the ability to rise above it despite the uncertainty and chaos of change, have no consensus among the assessors and their value is 0.00. Thus, these two items were dropped as experts felt these two attributes were not suitable for CE graduates. The other ten attributes show 100% agreement between the assessors. This result shows that 10 attributes of leadership skills need to be pursued by entry-level civil engineers.

Table 5. Expert's agreement for leadership skill construct

Attributes	Raters			% Agreement
	A	B	C	
Ability to lead a project	1	1	1	1.00
Have a willingness to take charge when needed	1	1	1	1.00
Ability to deliver expected results	1	1	1	1.00
Ability to work with and organize people from different backgrounds in work-related situations	1	1	1	1.00
Ability to take risk of an action/decision	0	0	0	0.00
Ability to rise despite the uncertainty and chaos of change	0	0	0	0.00
Ability to identify strengths and weaknesses of team members	1	1	1	1.00
Ability to assign tasks to team members based on their abilities	1	1	1	1.00
Ability to instill trust among team members	1	1	1	1.00
Ability to instill respect among team members	1	1	1	1.00
Ability to tolerate the opinions or ideas of others	1	1	1	1.00
Ability to work under pressure	1	1	1	1.00

From the analysis in Table 6, it is found that only 8 out of 10 attributes are suitable for emotional intelligence skills with 100% agreement among the assessors. There were two attributes that did not agree to be concluded as attributes for emotional intelligence skills are the ability to control negative emotions effectively and the ability to establish mutually satisfying relationships with others.

The result from Table 7 revealed that four attributes have no consensus among the assessors with a value of 0.00, which is the ability to create originality in a product, the ability to identify one's potential, the willingness to seek answers, and the ability to have self-regulation in completing tasks. These four items were dropped as the attributes for creativity skills. One attribute with 67% agreement, which is the ability to instill artistic value, was considered to be retained. The other six attributes show 100% agreement between the assessors. This result shows that seven attributes of creativity skills are needed for entry-level civil engineers to thrive in 4IR.

Table 6. Expert's agreement for emotional intelligence skill construct

Attributes	Raters			% Agreement
	A	B	C	
Ability to know and acknowledge own feelings/emotions	1	1	1	1.00
Ability to adapt to new conditions	1	1	1	1.00
Ability to adapt to different work settings	1	1	1	1.00
Ability to control negative emotions effectively	0	0	0	0.00
Ability to solve personal and interpersonal problems effectively	1	1	1	1.00
Ability to be positive and look at the brighter side of life	1	1	1	1.00
Ability to express and handle own emotions appropriately	1	1	1	1.00
Ability to establish mutually satisfying relationships with others	0	0	0	0.00
Ability to find a balance between work and life	1	1	1	1.00
Ability to perceive and understand the emotions of people around them	1	1	1	1.00

Table 7. Expert's agreement for creativity skill construct

Attributes	Raters			% Agreement
	A	B	C	
Ability to create originality of a product	0	0	0	0.00
Ability to identify own' potential	0	0	0	0.00
Ability to seek ideas to solve a problem	1	1	1	1.00
Ability to give alternative ways of solving problems	1	1	1	1.00
Ability to make a judgment in solving a problem	1	1	1	1.00
Ability to instill the artistic value	0	1	1	0.67
Ability to think outside of the box	1	1	1	1.00
Have a willingness to seek the answers	0	0	0	0.00
Ability to have self-regulation in completing a task	0	0	0	0.00
Ability to create new a better products or systems of digital artifacts and materials	1	1	1	1.00
Ability to propose a more effective work process	1	1	1	1.00

Table 8 shows that five attributes of critical thinking skills show the value of the agreement is 1.00, which means the assessor has reached the consent of the assessors. There were two items with 0.00% agreement, which are the ability to anticipate flaws, weaknesses (negative), or strengths (positive) of an argument or an action, and the ability to suspend or revise personal judgment about an issue or solution, were dropped as the attributes for critical thinking skills. Graduates in civil engineering are expected to equip themselves with all the five agreed attributes to be hired as entry-level civil engineers in the 4IR working environment.

Table 8. Expert's agreement for critical thinking skill construct

Attributes	Raters			% Agreement
	A	B	C	
Ability to develop a logical argument with appropriate evidence	1	1	1	1.00
Ability to be firm on own opinion or idea and deliver them in a good manner	1	1	1	1.00
Ability to analyze the quality of argument or actions	1	1	1	1.00
Ability to anticipate flaws, weaknesses (negative), or strengths (positive) of an argument or an action	0	0	0	0.00
Ability to find and/or retrieve new information	1	1	1	1.00
Ability to use data or information	1	1	1	1.00
Ability to suspend or revise personal judgment about an issue or solution	0	0	0	0.00

Adaptability skills are referred to as the interaction of an individual with their living environment and the linkage with the non-deterministic problem faced by an individual [27]. From the analysis in Table 9, it is found that only five attributes are suitable for adaptability skills with 100% agreement among the assessors. One attribute that did not agree to be concluded as an attribute for adaptability skills is the ability to come up with strategies that individuals employ to influence different settings.

Table 9. Expert's agreement for adaptability skill construct

Attributes	Raters			% Agreement
	A	B	C	
Have a willingness towards continuous learning to seek knowledge	1	1	1	1.00
Ability to be positive and look at the brighter side of life.	1	1	1	1.00
Ability to coop and blend in with working norms, and values	1	1	1	1.00
Ability to display high work spirit	1	1	1	1.00
Ability to work with people from different backgrounds in work-related situations	1	1	1	1.00
Ability to come out with strategies that individuals employ to influence different settings	0	0	0	0.00

The result from Table 10 revealed that six attributes have no consensus among the assessors with a value of 0.00, which are the ability to suspend or revise personal judgment about issues or solutions, the ability to communicate through digital media and spaces, the ability to adapt and develop new practices with digital technology, the ability to have integrity when using digital information, the ability to interpret digital information and the ability to judge the quality of digital information. The other six attributes show 100% agreement between the assessors. Entry-level civil engineers can perform well in digital skills by acquiring all six attributes of digital skills.

Table 10. Expert's agreement for digital skill construct

Attributes	Raters			% Agreement
	A	B	C	
Ability to suspend or revise personal judgment about an issue or solution	0	0	0	0.00
Ability to design and/or create new digital artifacts and materials	1	1	1	1.00
Ability to use digital data through the use of an appropriate medium	1	1	1	1.00
Ability to communicate through digital media and spaces	0	0	0	0.00
Ability to find and/or retrieve information by using technology	1	1	1	1.00
Ability to convey information clearly to an audience	1	1	1	1.00
Ability to adapt and develop new practices with digital technology	0	0	0	0.00
Ability to develop a positive digital identity or identities	1	1	1	1.00
Ability to control the boundaries when using the technology	1	1	1	1.00
Ability to have integrity when using digital information	0	0	0	0.00
Ability to interpret digital information	0	0	0	0.00
Ability to judge the quality of digital information	0	0	0	0.00

Table 11 shows that five out of six attributes of management skill show the value of the agreement is 1.00, which means the assessor has reached the consent of the assessors. Only one attribute was dropped as the attribute for management skill, which is having good social skills towards others (0.00 agreement). Graduates in civil engineering are expected to equip themselves with all the five agreed attributes to be hired as entry-level civil engineers in a 4IR working environment and perform the task as competent civil engineers.

Table 11. Expert's agreement for management skill construct

Attributes	Raters			% Agreement
	A	B	C	
Ability to manage time effectively	1	1	1	1.00
Ability to have good work discipline	1	1	1	1.00
Ability to manage work or tasks according to the given procedure	1	1	1	1.00
Ability to use technical knowledge in completing work or task	1	1	1	1.00
Have good social skills toward others	0	0	0	0.00
Ability to manage own potential to achieve certain goals	1	1	1	1.00

Next, the value of the agreement coefficient of the Fleiss Kappa index was used to validate each construct and attribute formulated based on the analysis of previous studies and interviews. The results of the Fleiss Kappa analysis and the level of agreement for each construct are shown in Table 12. The values of the Fleiss Kappa coefficient obtained from constructs are shown as: i) Communication skills=1.00 at a very good agreement level; ii) Problem-solving skills=1.00 at a very good agreement level; iii) Leadership skills=0.70 at a good agreement level; iv) Emotional intelligence skills=0.67 at a good agreement level; v) Creativity skills=0.54 at a moderate agreement level; vi) Pilot thinking skills=0.55 at a moderate agreement level; vii) Adaptability skills=0.71 at a good agreement level; viii) Digital skills=0.33 at a moderately weak agreement level; and ix) Management skills=0.71 at a good agreement level. The value of the overall Fleiss Kappa index agreement coefficient for 4IR generic skill constructs and attributes was 0.61, which was at a good level. All three experts agreed and verified the attributes of nine constructs of 4IR generic skills for civil engineering graduates formulated in this study. Based on the findings, nine constructs of GS4IR with 58 attributes have been highlighted and verified by the experts in the civil engineering field as the generic skills to be instilled among civil engineering graduates as shown in Figure 2.

Table 12. Fleiss Kappa's coefficient value index for each construct

Attributes	Raters		$P_a$	$P_r$	$K_f$	Level of agreement
	Yes	No				
Communication skill	21	0	1.00	0.50	1.00	Very good
Problem-solving skill	15	0	1.00	0.50	1.00	Very good
Leadership skill	27	6	0.82	0.41	0.70	Good
Emotional intelligence skill	24	6	0.80	0.40	0.67	Good
Creativity skill	21	9	0.70	0.35	0.54	Moderate
Critical thinking skill	15	6	0.71	0.36	0.55	Moderate
Adaptability skill	15	3	0.83	0.42	0.71	Good
Digital skill	18	18	0.50	0.25	0.33	Moderately weak
Management skill	15	3	0.83	0.42	0.71	Good
Overall	174	54	0.76	0.38	0.61	Good

From the finding, the comparison of existing generic skills highlighted by [20] to the findings of this study shows a degree of similarity between three types of existing generic skills and 4IR generic skills. Initially, six generic skills were highlighted to be possessed by civil engineering graduates. The skills are problem-solving, ethics, communication skills, individual and teamwork, lifelong learning, and project management skill. From the comparison, three of the existing generic skills namely problem-solving skills, communication skills, and management skills are the skills that remain relevant to be instilled among civil engineering graduates to become an entry-level civil engineer in a 4IR work setting. This finding is consistent with [28], who stated that while there are some specific general skills in 4IR that are still relevant, there is a need for some changes due to the growth of 4IR technology.

Meanwhile, the other three existing generic skills namely ethics, individual and teamwork skills, as well as a lifelong learning skill, were determined to be unsuitable for inclusion in the civil engineering curriculum and should be replaced by 4IR generic skills, which include critical thinking skill, creativity skill, adaptability skill, leadership skill, emotional intelligence skill, and digital skill. The findings from this study

showed that some generic skills that were previously not prioritized have become a key skill needed by industries among civil engineering graduates. This is congruent with claims by [1], [9] that the wind of change brought by 4IR has rendered some talents redundant or overlapping, while others are perceived as more important or needed by the industry. As a result, it is proposed that the requirement for and use of current generic skills in the curriculum of civil engineering studies based on previous research [29], [30] be improved [1], [9], [31]. It may be argued that each field of employment necessitates its own set of 4IR generic abilities to meet the needs and desires of employers who are in charge of hiring prospective employees.

The identification of this type of 4IR generic skill can be used to guide the application of new skills following industry demand for future-proof graduates, as proposed by [32]. In further, it is proposed that an emphasis on nine 4IR generic abilities be incorporated in the development of a future available curriculum for the area of civil engineering. These initiatives will help to lessen the problem of skills mismatch and the unemployment rate among engineering graduates, particularly in the field of civil engineering.

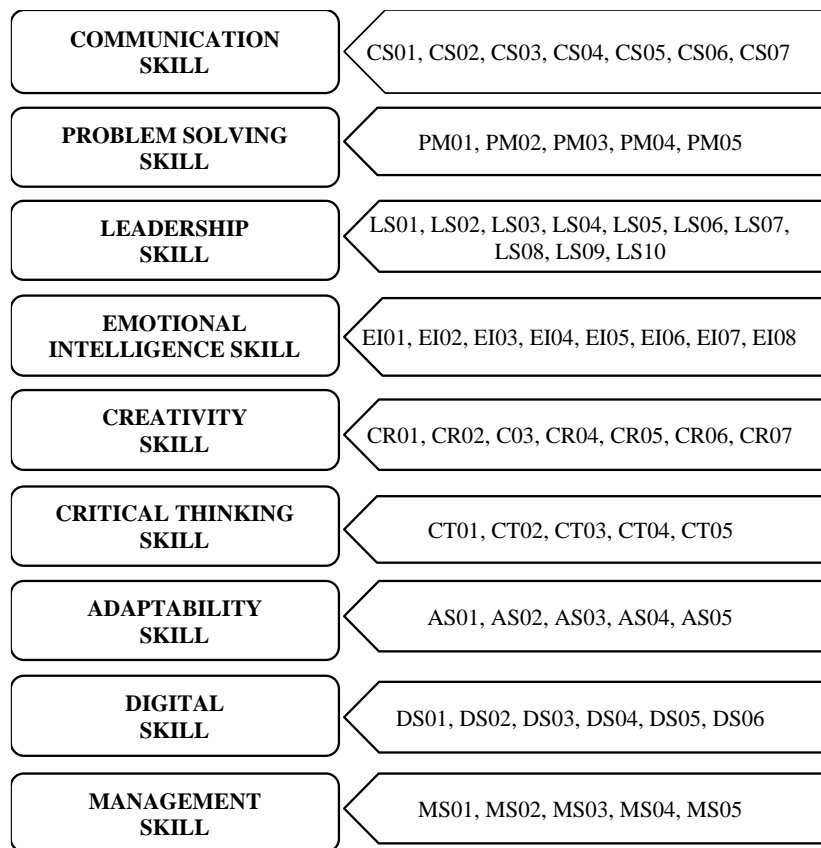


Figure 2. Constructs and attributes of GS4IR for engineering graduates

#### 4. CONCLUSION

4IR generic skills were the main focus of this study. 4IR generic skills are seen as tools that can help graduates and prospective employees get and keep their jobs. By acquiring these skills, graduates will be able to secure a job as entry-level engineers as soon as they finish their studies at the university level. Further, the findings of this study will be used by researchers to develop a framework of 4IR generic skills (GS4IR) for Civil Engineering Graduates consisting of 4IR generic skills as well as the details of its attributes. The 4IR generic skills framework is a guide for new graduates or prospective engineers to be accepted to work in the field of civil engineering as well as a guide for employers and institutions of higher learning as well. With this framework, graduates, employers, and institutions of higher learning can apply 4IR generic skills during their studies or in the workplace.






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