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**READINESS ASSESSMENT OF PUBLIC UNIVERSITY IN BANGLADESH
FOR EDUCATION 4.0: A CASE STUDY OF SHAHJALAL UNIVERSITY OF
SCIENCE AND TECHNOLOGY – SYLHET, BANGLADESH**

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KUS: ICSTEM4IR-22/0139

Manuscript submitted: June 20, 2022

Accepted: September 28, 2022

Abstract

In order to get the benefits of Industry 4.0 (4ir) we need the graduates who are able to face the challenges of 4ir. As the universities are the main sources of producing graduates, they should produce adaptable graduates of 4ir. The 4ir demands such a system of higher education where each and every stakeholders especially educators and learners should be connected in a globalized automated environment, networked, virtualized and flexible. In the paradigm of 4ir learners should learn to learn the sources of learning how to build knowledge and skills within the process of teaching –learning. The study aims to identify the dimensions of E4.0 corresponding to 4ir and to assess the readiness of Shahjalal University of Science and Technology (SUST) is one of 50 public universities of Bangladesh. At present there are 28 disciplines in six schools of studies in SUST and among them 20 departments have been selected for the study based on minimum 10 years of establishment. The assessment has been focused on four aspects mainly curriculum, teacher (faculty), intuitional qualification and logistic supports in terms of E4.0. In conducting the study data from collected 120 teachers and graduate students with a structured questionnaire. The questionnaire was five point scales. The collected data was analyzed with SPSS and mainly frequency in each dimension was found and finally factor analysis was done to find the factors affecting E4.0. The frequency distribution showed that Robotic Process Automation aspects ranked first following cloud computing, data analytics, IoT, AI, and BCT. The factor analysis showed that seventeen aspects have been considered as important and the top most five aspects are fees and rewards, data as a service, software as a service, AI extraction and user device.

Keywords: Industry 4.0, Education 4.0, Advancement of E4.0 of, SUST

Introduction

After the emergence Industry 4.0 (4ir) by a German scientists group in 2011(Hermann et al., 2016) a rapid change in every aspects social life as well as in daily life have been looked. Education 4.0 (E4.0) is the parallel

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DOI: <https://doi.org/10.53808/KUS.2022.ICSTEM4IR.0139-se>

development of 4ir. In order to get the benefits of 4ir where human and technologies are integrated to unveil the promising possibilities E4.0 has become the leaning of discourse by scholars as the path of forthcoming education (Lasi, H *et al.*, 2014). The universities should provide graduates who are not only competent in the use of evolving skills but also the values associated with them (Nelles *et.al*, 2016). In the archetype of 4ir learners should learn to learn the sources of learning how to build knowledge and skills within the process of teaching–learning (Gehrke L, Kühn AT *et al.*, 2015). The ASEAN countries (Malaysia, Vietnam, and Thailand) have developed blueprint in their higher education for alignment with global trend i.e.E4.0. Bangladesh has implemented Higher Education Quality Enhancement Projects with the support of World Bank and finally enacted Bangladesh Accreditation Council (BAC) Act-2107 for ensuring quality in higher education in Bangladesh to get international accreditation. BAC has established ten criterion for getting accreditation and among them governance (vision and mission i.e. strategic planning) curriculum, facilities and resources, faculty / professional staff, research and scholarly activities are most important all are aligned with E4.0. The universities are the central of education and most of them are fronting tests to prepare the students in meeting shifting education needs in the era of E4.0 that has impetus to educational transformation (Kin and Kareem, 2019).

The first criterion of E4.0 is flipped class room in which aims to teach the students strategically in home and class room. The core components of E4.0 are students' competencies; learning methods (flipped class room); practices of information and announcement know-hows in teaching - learning process (Perez and Montoya, 2022).

Without the adaptation of E4.0 universities will not be accredited by BAC and international bodies. Consequently the graduates will not be employed globally even nationally also because the national and multinational corporation working in Bangladesh are transforming into 4ir rapidly. Therefore the time is now ripe to measure the capability of the institute of higher education in terms of E4.0 in Bangladesh. There are 50 public universities in Bangladesh and Shahjalal University of Science and Technology (SUST) is first in its nature which has 28 disciplines and out of them 20 disciplines is sampled in the study based on minimum 10 years of establishment covering more than 70% of SUST. The study is directly relevant to SDGs#4.

Literature Review

The E4.0 is the concurrent of 4ir. There are four industrial revolutions happened over the ages when the first is 'instrumental age' the second one is 'power saving age' the third one is 'automated age', the fourth one is 'internet age' called the fourth industrial revolution (4ir) or the period of innovation (Peters, 2017). The 4ir demands new skilled and talented workforce and society has evolved accordingly. Moravec (2013) compared this approaches as the development of society 1.0, 2.0, 3.0 and 4.0 correspondingly with Industry 1.0, 2.0, 3.0 and 4.0. With the change of production process and society the content and concept of education has prolonged its meanings and some scholars opined that this changed of Education has come through as E1.0, E2.0, E3.0 and E4.0. Harkins (2008) viewed that in the prototype of E4.0 the meaning of education, technology, teaching, schools and teachers have been redefined. In the archetype of E4.0 means innovation process, technology means continuous changes by inputs from students, teaching means positive innovation feedback loops, schools means globally networked and teacher means sources of innovation producing. The characteristics of E4.0 explored by Beyza Himmetoglu *et al.* (2020) are: free entree, customized education, and psychological renovation, incorporation of numeral machineries to education, unified learning environment, lifetime education, explorative education and multi-disciplinary education. They also explored required qualifications of students in E4.0 are: teamwork and communication skills, high-tech skills and personal characteristics, and expected qualifications from teachers as well as from school are scientific skills, leadership skills, all-time learning skills and school's capability. Woolf *et al.*(2013) worried about some majestic trials regarding E4.0 as :(i) difficulties of computer-generated mentors for every learner includes - ubiquitous support that integrates user modeling, social imitation and knowledge depiction; (ii) alarming on g 21st century skills includes: support learners with self-direction, self-assessment, teamwork and more;

(iii) investigation and interaction of data bring together the massive figure of data about individual learning, social aspects, learning frameworks and personal situations; (iv) anxieties about the supports for global classrooms includes : surge the inter-connections and accessibility of classrooms world- wide; (v) concerns on all-time and life-wide machineries contains : learning outside of the classroom and into the learner's life outside of school.

Conceptual Framework of E4.0 in the Interface of 4ir

Ellahi et al.(2019) opined that in order to overcome from the current state, universities should prepare such a curriculum where latest knowledge and skills will be given emphasis in producing the graduates and the modern aspects education are big data analytics, artificial intelligence, augmented reality, internet of things, cloud computing and other advancements also. Karim and Ramparsad (2017) found that reception of technology like cloud computing in tertiary education in developing countries is very limited from others sectors. Mendoza et al. (2018) proposed the curriculum for engineering education to meet 4ir and have given priority on competencies, multidisciplinary collaboration, high technology based education and talent formation. Giang et al.(2017) presented a model for educational robotics and found that teachers has a high level approval for the robotics devised and in the proposed framework should appropriately reflect the teachers' need than did conventional methods. The quality of a school depends on curricula, learning process, graduate competencies, staff evaluation and education, infrastructure and funding (Cahyono et al., 2015). Coskun et al. (2019) suggested that to adapt the advancement of 4ir education system should be aligned to all the dimensions of 4ir and it should started in curriculum, laboratory and to students' learning system. Halili Siti Hajar(2019) provided that in all aspects of 4ir - 3D silk-screening, bigger authenticity, simulated realism, cloud computing, hologram, biometrics, multi-touch LCD screen, internet of things, artificial intelligence, big data and qr-code can be used for educational purposes and that is called E4.0. Promyoo(2019) emphasized that the curricula for engineering education should be included the digital technologies of 4ir. Buyya, Rajkumar, et al (2009) opined that cloud computing has application in all area of life including education. Bulla et al (2016) identified the dimensions of cloud computing Software as a Service (SaaS), Platfor as a Service (PaaS) and Infrastructure as a Service (IaaS). Hussin (2018) E4.0 is a respond to 4ir. Lase (2019) found that the current and future syllabuses contain the required abilities of students such as life skills and the capability to live together and think critically and creatively. Yadav (2014) argued that cloud computing is an extension of distributed computing as running a program over many network connected computers. NIST (US National Institute of Standards and Technology) defines cloud computing as a model for permitting universal, suitable, on-demand network access to a shared pool of configurable computing resources. Considering the above literature the E4.0 in the interface of 4ir is given in Table 1.

Materials and Method

Study area

The study is based on Shahjalal University of Science and Technology, Sylhet of Bangladesh.

Sampling and sample size

The population of the study is the graduates students and faculties of SUST. Further among all the departments 20 Departments have been chosen purposively as these are 10 or more than 10 years old. Considering this convenient sampling has been used with the structured questionnaire and total 390 respondents were interviewed using formula of large population suggested by Fisher Fisher et al., (1998) where minimum sample is 384.

Methods of data analysis

Data has been gathered from 390 faculty and graduate students. The questionnaire was scaling on 5 point as follows: not yet ready=0; 0-20% ready =1; 20%-40% ready =2; 40%-60% ready =3; 60%-80% ready = 4;

800%-100% ready =5. The collected data was analyzed with SPSS and mainly frequency in each dimension was found and finally factor analysis was done to find the factors affecting E4.0.

Table-1. The dimensions of E4.0 in corresponding to 4ir

Aspects of 4ir	Components of 4ir	Dimensions of E4.0
1.Data Analytics(DA)	It involves exploring data sets with the aim of creating concrete conclusions. It requires <ul style="list-style-type: none"> ➤ Big Data ➤ Data Visualization ➤ Predictive Analysis ➤ Data Warehousing 	<ol style="list-style-type: none"> 1. Data acquisition(DAQ)-sensors, 2. DAQ boards and devices, Computer and software, 3. Data security, 4. Data governance and standards 5. Insight analysis 6. Data storage 7. Data visualization 8. Data optimization
2.Internet of Things (IoT)	It is set of components that are required for the arrangement of applications which connects devices by monitoring and controlling them. The four components of it are: <ul style="list-style-type: none"> ➤ Sensor/Devices ➤ Connectivity ➤ Data processing ➤ User interface 	<ol style="list-style-type: none"> 9.Keen E-learning application with IoT 10. Smooth IoT based class room; 11. Shrewd IoT based lab room; 12.IoT sensors for notes sharing ; 13 IoT sensors for mobile devices; sharing; 14. Hotspot for campus 15. Smart parking; 16.Smart inventory; 17.Smart lighting; 18. smart tracking of students; 19. Smart corridors with info boards and data centers; 20. Smart health service; 21. Smart Housing; 22. Smart dining; 23. Smart transport and trafficking; 24. Smart safety and security; 25. Smart locating; 26. Smart social services;
3.Robotic Process Automation (RPA)	It is an emerging technology to facilitate and simplify enterprise operations. It has four components: <ul style="list-style-type: none"> ➤ The Manipulator ➤ The Controller ➤ The Human interface device ➤ Power supply 	<ol style="list-style-type: none"> 27. Programming ; 28. User device; 29. Assembly; 30. Sensors; 31. Actuators;

4.Blockchain Technology(BCT)	<p>It is a share of immutable ledger that facilitates the process of recording transactions and tracking assets in a business network. The eight components of it are:</p> <ul style="list-style-type: none"> ➤ Peer network ➤ Smart Contract ➤ Membership ➤ Events ➤ Ledger ➤ System integration ➤ Wallet ➤ System management 	<p>32. Identity and students' records; 33. New pedagogy; 34. Fees and rewards;</p>
5.Cloud Computing(CLC)	<p>It is the practice of using a network of remote servers hosted on the internet to store, manage, and process data, rather than a local server or a personal computer. The nine components are:</p> <ul style="list-style-type: none"> ➤ Client infrastructure ➤ Application ➤ Service ➤ Runtime ➤ Storage ➤ Infrastructure ➤ Management ➤ Security ➤ Internet 	<p>35. Software as a service (SaaS); 36. Platform as a service (SaaS); 37. Infrastructure as a service (IaaS); 38. Data as a service(DaaS);</p>
6.Artificial Intelligent(AI)	<p>It means simulation of intelligence processes by machines especially computer system. Its three components are:</p> <ul style="list-style-type: none"> ➤ Speech recognition ➤ Computer vision ➤ Natural language processing 	<p>39. AI-System –Algorithm –classifying and matching –deep learning- 40. AI- Extraction- feedback-AI-supported Reasoning - Adaptive learning 41. AI-application: Technological adoption –categorization -</p>

Analyses and Findings

The findings under six aspects of E4.0 corresponding to 4.ir are as follows:

Big data analytics

The big data means the huge, massive magnitudes of data both in digital and physical formats that can be stored in various stores as required by the users (Sedigheh *et al.*, 2014). Learners, educators, researchers and others stakeholders get benefits from it in teaching and learning processes. Data analysis for E4.0 helps in making a road map for an operating model –tracking the students, employee, determining Key Performance Indicators (KPI) and formulation of strategy to fulfill the organization's vision and mission. It provides information about –students enrollment in terms of semester, course, course trending or obsolete, student satisfaction effectiveness, designing a better curriculum, students transfer, drop out or failure to complete the

course or semester, modeling for faculty, research, administrative and students groups who are looking out for genuine results about the university rankings, based on which they make their decisions, ranking the teachers and universities. There are eight aspects of E4.0 in this regard:

Table 2. Frequency Distribution of Data Analytics

Dimension	0%	0-20%	20-40%	40-60%	60-80%	80-100%
Data acquisition (DAQ) sensors	0	0	3	38	37	42
DAQ boards and devices	0	2	38	42	38	0
Data security	0	38	42	37	3	0
Data governance and standards	0	60	58	2	0	0
Insight Analysis	38	43	39		0	0
Data storage	0	59	60	1	0	0
Data visualization	0	40	43	37	0	0
Data optimization	32	29	30	29	0	0
Average	8.75	33.88	39.13	23.25	11.14	5.25

The average level of development is 1.74(20-40%) and highest advancement in DAQ 2.75 (40%-60%) following data visualization 1.98 (20% to 40%) that means on average data analytics is 20% - 40% readiness in SUST.

Internet of things (IoT)

The evolution of internet enables the peoples to interact with world through computers, laptops, smartphones and other devices. Today with the evolution of the global Internet, a wide range of devices such as home appliances, cars, different electrical equipment as well as varieties of smart devices could communicate using the services of the Internet as well thus creating the Internet of Things (IoT). IoT in education provides architecture of communication by which teacher, students and all stakeholders able to communicate each other using wired or wireless devices in home and office in 24/7 with reduced energy. As a result campus leaders are able to derive to generate more value from the continuous stream of data and knowledge. It helps smart campuses to complement and fit with the overall smart environment strategy, allowing educational institutions to achieve full productivity, promote sustainability, and enhance their constituents' everyday conditions (Vinayachandra & Krishna Prasad K, 2020).

Table 3 showed the IoT of SUST and it is found that on five point scale the average point is 1.53 (0% to 20%) and the top most is Smart E-Learning application 3.98 (about 80%) IoT sensors for mobile devices sharing 3.47 (60% to 80%) that means SUST is about 0% to 20% ready in respect of IoT.

Robotic process automation (RPA)

Robotic process automation is the technology of software robots being programmed to undertake some of our daily tasks and reduced our time It helps teachers, educators, students as well as parents directly or indirectly by sorting out the registration, reduction in processing time, automating attendance and making sense of it all and improved administration (Palanivel, and Joseph,2020). The data on this aspect is given in Table 4. Table -4 showed the RPA of SUST and it is found that on five point scale the average point is 2.70 (40% to 60%) and the top most is user device is 3.48 (40% to 60%) and the lowest is actuators 2.0 (20% 40%). Therefore, the readiness of SUST in respect of RPA is 40% to 60%.

Table-3. Frequency distribution of Internet of Things

Dimension	0%	0-20%	20-40%	40-60%	60-80%	80-100%
Smart E-Learning application with IoT	0	0	3	38	37	42
Smart IoT based class room	36	42	40	2	0	0
Smart IoT based lab room	36	43	39	2	0	0
IoT sensors for notes sharing	56	64	0	0	0	0
IoT sensors for mobile devices sharing	0	0		64	56	0
Hotspot for campus	0	0	0	63	57	0
Smart parking	56	64	0	0	0	0
Smart inventory	58	62	0	0	0	0
Smart lighting	57	63	0	0	0	0
Smart tracking	40	43	37	0	0	0
Smart corridor	0	58	62	0	0	0
Smart health	57	63	0	0	0	0
Smart housing	56	64	0	0	0	0
Smart dining	58	62	0	0	0	0
Smart transport	57	63	0	0	0	0
Smart safety	0	28	31	32	29	0
Smart location	0	2	40	42	36	0
Smart social	0	38	43	39	0	0
Average	31.5	42.17	17.35	15.67	11.95	2.33

Table -4: Frequency distribution of RPA

Dimension	0%	0-20%	20-40%	40-60%	60-80%	80-100%
Programming	0	0	0	62	48	0
User Device	0	0	0	62	58	0
Assembly	0	39	43	38		
sensor	0	42	41	37	0	0
Actuators	0	38	44	38	0	0
Average	0	23.8	25.6	47.4	26.5	0

Block chain technology (BCT)

The usages of BCT in education sector would improve teaching and learning activities and encourage partnership among the all kinds of participants who are intended to get their benefits by getting information. The main outputs of BCT are- e-transcripts, digital degrees and certification, cloud storage, identity management (Mendaz and Bayyou , 2019). The data on this regard is given in Table 5:

Table 5. Frequency distribution of Block Chain

Dimension	0%	0-20%	20-40%	40-60%	60-80%
Identify and students records	57	63	0	0	0
New pedagogy	0	59	61	0	0
Fees and rewards	0	39	41	40	0
Average	19	53.67	34	13.33	0

Table 5 shows that the average point on block chain is 1.35 (0% to 20%) and highest in fees and rewards 2.01(40% to 60%). The average readiness is very low.

Cloud computing (CLC)

CLC is an internet-based computing systems in which public resources, software and information are delivered as a service connecting devices on demand. Free or low-cost cloud-based services are already been in using by learners and educators in various purposes i.e. Google Apps, YouTube, Twitter and Drop box(Yadav, 2014; Bullaet et al., 2016). The main users of a typical CLC in higher education are included students, faculty, administrative staff, and examination and admission branches. In CLC participants can get at home and college and 24 x 7. It makes possible for teachers to identify problem areas in which students tend to make mistakes and following it teachers can improve teaching materials and methods.

Table 6. Frequency distribution of Cloud Computing

Dimension	0%	0-20%	20-40%	40-60%	60-80%
Software as a service	0	40	44	36	0
Platform as a service	39	41	38	2	0
Infrastructure as a service	0	29	30	30	31
Data as a service	0	40	43	37	0
Average	9.75	37.5	38.75	26.25	7.75

Table-6 shows the data on cloud computing and the average is 1.97(20%40%) and the highest on infrastructure 2.53 (40% to 60%). The readiness is about 40% on cloud computing of SUST.

Artificial intelligence (AI)

AI is an arrangement with computer and computer related technologies for forming web-based and online intelligent education systems and finally we can use of embedded computer systems along with other technologies to perform instructors' duties and functions independently or with instructors. In these platforms, mentors are able to perform their duties in reviewing and grading students' assignments more effectively and efficiently, and achieve higher quality in their teaching activities. (Chen et al, 2020). The data on this dimension is given in Table 7.

Table-7 shows that the average AI is 1.48 and varied between 1.45 in respect of AI-application - technological adaptation –categorization and 1.51 on AI- Extraction: feedback -AI supported Reasoning - Adaptive Learning.

Table 7. Frequency distribution on Artificial Intelligence

Dimension	0%	0-20%	20-40%	40-60%	60-80%	80-100%
AI- System: Algorithm Classifying and matching deep learning	32	29	29	30	0	0
AI- Extraction : feedback -AI supported Reasoning -Adaptive Learning	30	30	29	31		0
AI-application: Technological adaptation -categorization	32	32	26	30	0	0
Average	31.33	30.33	28	30.33	0	0

Over-all

The six aspects of E4.0 is summarized below in table -8

Table 8. Over- all ranking of all aspects of E4.0

Aspects	Average	Rank
Data Analytics	1.74	Third
Internet of Things	1.53	Fourth
Robotic Process Automation	2.70	First
Block Chain	1.35	Sixth
cloud computing	1.87	second
Artificial Intelligence	1.48	Fifth

Factor analysis

Exploratory Factor Analysis has been conducted using SPSS with Varimax rotation for finding the most important factors related to the specific area of the collected information. Factor analysis is conducted on each factor of based on the Eigen value more than 1, hence Kaiser (1960) explained that Eigen value greater than 1 is the cutoff point and factors with higher communalities important (Child, 2006). Reliability analysis has been conducted prior to these analyses. For data to be considered reliable, the value of its Cronbach alpha should be >0.7 (Nunnally, 1978). The reliability analysis of the responses are tested against the standard and found the data are reliable. The scree plot with Eigen value is give in Figure 1. From Figure 1 it is found that the seventeen items had most influence which are presented in Table 9.

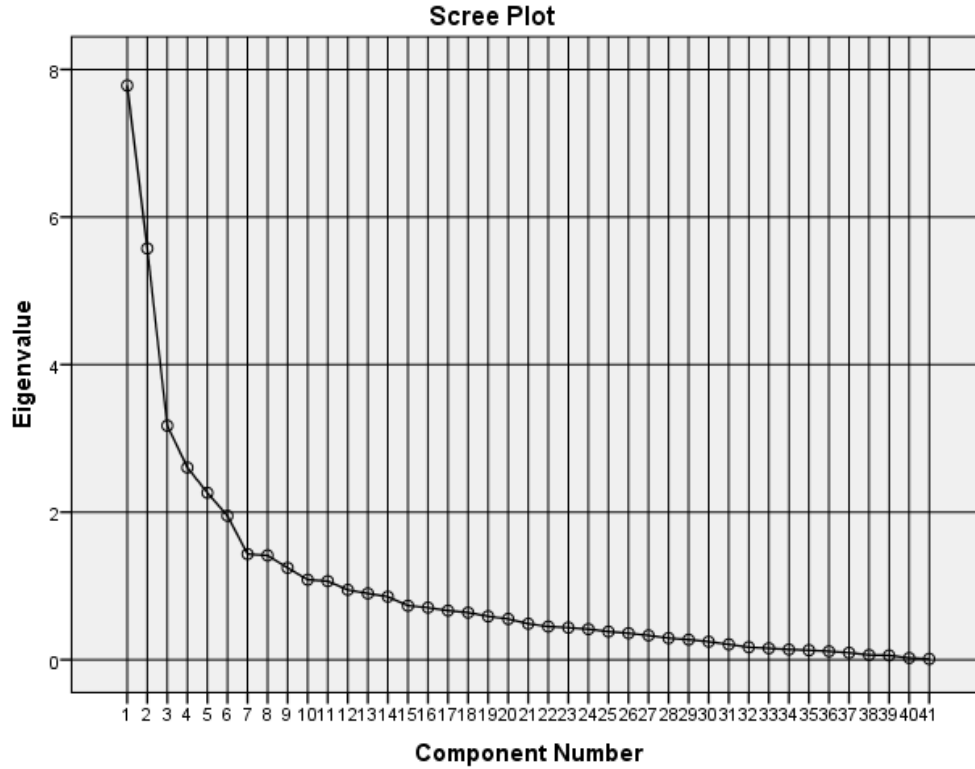


Figure 1. Scree plot with Eigen value.

Table-9: Most Important Items

Items	Factor 1		Factor 2		Factor 3		Factor 4		Factor 5		Factor 6	
	Communalities	Factor Loading	Communalities	Factor Loading	Communalities	Factor Loading	Communalities	Factor Loading	Communalities	Factor Loading	Communalities	Factor Loading
Data_optimization_8	.781	.851										
Data_storage_6	.779	.877										
Data_acquisition_1	.696	.797										
Data_security_3	.684	.769										
Smart_health_20			.845	.901								
Smart_dining_22			.798	.845								
Smart_Housing_21			.797	.803								

Smart_parking_15			.786	.818								
Smart_inventory_16			.782	.736								
User_device_28					.844	.919						
Programming_27					.843	.918						
Fees_and_rewards_34							.986	.993				
Identity_and_students_32							.559	.742				
Data_as_a_service_38									.890	.941		
Software_as_a_service_35									.878	.935		
AI_Extraction_40											.875	.935
AI_application_41											.793	.859
Eigen Value	2.009	5.580	1.721	1.099	1.826	1.327						
Cumulative variance explained	66.310%	70.455%	62.621%	70.031%	71.566%	79.972%						

Table shows that among the most important items 4 belong to DIA, 5 belong to IoT and 2 from each of RPA, BIT, CLC and AI. Next table shows the ranking of these items based on the factor loading value.

Table 10. Ranking of the items

Rank	Factor	Items	Communalities	Factor Loading
1.	BCT	Fees_and_rewards_34	.986	.993
2.	CLC	Data_as_a_service_38	.890	.941
3.		Software_as_a_service_35	.878	.935
4.	AI	AI_Extraction_40	.875	.935
5.	RPA	User_device_28	.844	.919
6.		Programming_27	.843	.918
7.	IoT	Smart_health_20	.845	.901
8.	DIA	Data_storage_6	.779	.877
9.	AI	AI_application_41	.793	.859
10.	DIA	Data_optimization_8	.781	.851
11.	IoT	Smart_dining_22	.798	.845
12.		Smart_parking_15	.786	.818
13.		Smart_Housing_21	.797	.803
14.	DIA	Data_acquisition_1	.696	.797
15.		Data_security_3	.684	.769

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16.	BCT	Identity_and_students_32	.559	.742
17.	IoT	Smart_inventory_16	.782	.736

Table shows that most influencing sub-factor is Fees and rewards which belongs to BCT, then data as a service and Software as a service under CLC.

Suggestions and Conclusion

The study presented the conceptual framework of E4.0 and identified 41 dimensions of E4.0 in the interface of 4ir. The frequency distribution showed that Robotic Process Automation aspects ranked first following cloud computing, data analytics, IoT, AI, and BCT. The factor analysis showed that seventeen aspects have been considered as important and the top most five aspects are fees and rewards, data as a service, software as a service, AI extraction and user device. Therefore, the study suggested that the authority should give attention on the cloud computing, data analytics, IoT, AI, and BCT in the archetype of E.4.

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