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Reflecting trends of the contemporary academic landscape in the context of Higher Education 4.0

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The world has become a place where information can be accessed quickly and disseminated widely in the knowledge society in parallel with the speed of technological advancements. The shift of focus toward knowledge economy has necessitated the transformation of higher education institutions to meet the demands of the current era, as indicated by the commencement of the 4th industrial revolution, also referred to as Industry 4.0 (I4.0). Universities are now expected to equip their graduates with necessary competencies for the jobs of the future so that they will fulfill the professional demands and requirements of I4.0. To be able to achieve this, modifications have taken place in many spheres of higher education including but not limited to the adoption of new instructional methodologies, changes in the teaching and learning environment and the redefinition of student competencies in line with the requirements of the current era. In parallel with this approach, the aim of the European Universities Initiative (EUI) is to transform the quality and competitiveness of European higher education where the alliances are expected to become universities of the future with a specific focus on student-centered curricula and innovative teaching approaches. To this end, employing a comparative survey design, this study will explore perceptions of academics in a European University Alliance (EUA) concerning the extent to which already existing academic practices align with good practice indicators defined for Higher Education 4.0 (HE4.0). Data was collected from an EUA through a statistically valid and reliable scale devised by the researcher. In total, 161 academics from nine different European Universities participated in the research. Factor analysis, validity and reliability testing, and comparative statistical methods (Kruskal Wallis-H, Mann Whitney-U, One-Way ANOVA, Independent Samples T Tests, Pearson Correlation) were performed for data analysis. The findings indicate that female academics and academics actively involved in EUA activities demonstrate higher awareness of good practice indicators in the scope of HE4.0. Being actively involved in EUAs to mainstream good academic practice across higher education institutions will contribute to keeping up with the rapidly changing academic landscape in the 4th industrial era.

KEYWORDS

Higher Education 4.0, University 4.0, European Universities Initiative, European University Alliances, 21st century student competencies

Introduction

There have been unprecedented alterations in many spheres of life in accordance with transition to I4.0, which is reported to have commenced in 2011. Industrial revolutions have direct influences on the society and educational institutions are expected to adopt and adapt to the changes taking place to serve to the needs of individuals, who are experiencing their effects. For example, when the first industrial revolution, Industry 1.0, took place, education was restricted to only a few individuals and its major goal was to cater for the needs of agricultural society. Now in I4.0, the primary aim of educational institutions is to serve to the needs of the digital society in the 21st century world. Needless to say, with their roles as change agents, it falls under the responsibility of universities to meet the needs of the era by raising qualified individuals with skills and competencies required in the 21st century workplace. Therefore, owing to the changing conditions taking place as a result of transition to I4.0, which takes into focus such constructs as Internet of Things, Artificial Intelligence, Virtual Reality, cloud computing and big data, “the university becomes different ‘another entity’ corresponding to the new ‘version of the world’” (Lapteva and Efimov, 2016, p. 2682). In this context, University 4.0 (U4.0) can be characterized as bio-digital university based on multiple intelligence model with meta-individual students and key categories of competence like creativity, ecosystem and business and with such key competencies as the ability to comprehend and solve local and global problems promoting the development of the ecosystem of the society (Madaliyeva et al., 2020).

Changing paradigms of higher education in the context of Industry 4.0

A new chapter has been introduced into our lives by I4.0 accompanied by global connectiveness and advanced technology, which has led to widespread access to higher education on a global scale and transformed the means through which students improve the competencies and skills that are necessary to excel in their professional lives (Göker, 2019). It is a fact that the 21st century workplace requires skills and competencies that are far different from those of the previous industrial revolution periods owing to aforementioned reasons (Ülker and Otrar, 2024). Within this scope, Demir et al. (2019) assert, considering the present circumstances, the competencies targeted in higher education do not currently correspond to employers’ expectations. While the gap between desired competencies, the courses and other opportunities for learning offered could be ignored for the present; unless necessary precautions are taken, the gap will start to create problems for students for approximately 10 years later, which requires revising existing curricula and making necessary changes and adaptations (Torun and Cengiz, 2019). The essential features of U4.0 can be summarized as below (Anand, 2020; Gavhane, 2018).

- Students have the opportunity to learn whenever and wherever they prefer in their own pace through a variety of e-learning tools. Flipped methodology enables interaction

during class while students have the chance to master theoretical information out of class hours.

- Personalized learning opportunities are offered, providing a platform for students to move on to more difficult tasks upon achievement of a certain level of proficiency.
- It is possible for students to select what they want to learn in that they can select their learning methods and tools although they do not have that much control over the curriculum.
- Students are involved in short-term projects to expose them to project-based learning experiences to practice skills that they will need in their future careers.
- Students are offered hands-on learning experiences through mentoring, collaborative projects and internships.
- Students are offered opportunities where they interpret data using their logic and applying theoretical information they learned.
- Students are evaluated through different means both during the actual learning process and while applying theoretical information.
- Student needs are in the center of curriculum design and their opinions are asked to keep curriculum effective and up-to-date.
- As students are expected to become more autonomous learners, the roles of instructors are expected change into guiding and facilitating students during the learning process.

The major goal of higher education is to meet students’ needs as well as matching them with those of the industry. To accomplish this, while providing the learners with high quality education, there needs to be a solid university-industry partnership to lay the foundations for curriculum to be designed in accordance with the demands of industry (Chitkara et al., 2020) as the aim of U4.0 is to raise competent graduates that will take part in the workforce of I4.0 (Pangarso, 2024). Within the scope of U4.0 practices, for the students to be able to conduct research and practice in real life situations, universities must collaborate with public or private companies (Kankaew, 2019). Also, joint courses could be created in cooperation with educational and industrial partners (Kulik et al., 2020) to be able to provide contemporary academic knowledge to students so that they are fine-tuned for the 21st century workplace.

It is a fact that providing the students with a variety of opportunities to develop inside and outside of the classroom leads to and improves student learning (Polkinghorne et al., 2017), which is one of the pillars of U4.0. To facilitate this, students are encouraged to engage in classroom activities (Latif et al., 2019), active or project-based learning, which enables them to apply knowledge to real-life problems. As part of this approach, the students must be asked to do research projects to enhance their problem-solving skills and involved in projects to be part of joint efforts and to establish networks (Kankaew, 2019). This will not only facilitate formation of communities of practice offering opportunities for more focused work but also improve students’ knowledge and skills. While relevant skills development could be considered the first step, as asserted by Dicker et al. (2019), the positive influence of career guidance offered to students cannot be overlooked. It is obvious that there needs to be an environment supportive of career growth in U4.0 (Nabokikh et al., 2019) to

facilitate students' transition to working life (Lukita et al., 2020). This requires incorporation of career guidance in any relevant form into school curricula.

As a consequence of transition to I4.0, "The human activity is shifted from the area of routine operations into the area of trial and search actions, critical and creative thinking, reconstruction of society and self-realization of an individual" (Lapteva and Efimov, 2016, p. 2686). The U4.0 model, accordingly, is based upon adjustments and modifications in higher education programs so that a high-level of expertise, scholarly activity, spirituality and integrity is achieved, advocating the protection of national identity while emphasizing the significance of global citizenship and students' social responsibility as active agents of change for not only their homeland but also for the society (Madaliyeva et al., 2020). Universities of the 4th industrial era are expected to respond to these prospects applying relevant means in their educational processes and practices. Within this framework, along with contemporary knowledge, relevant 21st century skills come to the forefront in line with prioritizing knowledge and skills-based education, as suggested by Chitkara et al. (2020). When education is based on knowledge and skills, there is a higher probability of matching the needs of the students with those of the industry, contributing to success in professional life in the 21st century.

In the current era, it is a must to raise graduates equipped with a variety of areas of knowledge and competencies that can be used in numerous fields and that will provide help to students to adjust socio-economic conditions, which change expeditiously (Kulik et al., 2020). A wide range of areas of knowledge and student skills and competencies have been articulated in the scope of university learning 4.0, some of which are creativity, critical thinking, problem solving, team work, cooperation, moral and ethics, technology literacy, foreign language (English), understanding of the world system, financial and economic knowledge, empathy, citizenship, oral and written communication skills, problem solving, essential subjects such as math, economic history, citizenship and governance, knowledge about the world, economics, accountability, digital economy, innovation and information technology, entrepreneurial mind-set and skills, organizational, time management, human knowledge and collaborative skills, awareness of the global policies and laws, methodological skills to be able to analyse and interpret big data (Buasuwan, 2018; Chitkara et al., 2020; Demir et al., 2019; Kankaew, 2019; Lukita et al., 2020). If I4.0 is considered as an iceberg, technical and technological skills and competencies that are highly emphasized in the related literature can be considered as the tip of the iceberg while soft skills can be considered as the part of the iceberg under water (Demir et al., 2019). Hence, it is of utmost importance to put emphasis on soft skills to meet the needs of the current era. These skills and competencies have been defined under different domains: digital skills, career and life skills and learning and innovation skills. As part of learning and innovation skills domain, what is referred to as 4 Cs, which are communication, creativity, collaboration and critical thinking have become prominent encompassing a variety of other skills involved in 21st century learning.

Needless to say, the aforementioned areas of knowledge, skills and competencies can only be offered in an appropriate teaching and learning environment. The teaching and learning environment should be designed in such a way that will enable flexibility to overcome the ambiguity caused by technology in the 4th industrial era as well as personalisation of students' learning experiences. Thus "University 4.0 provides autonomous management of learning processes based on the integration of the physical and digital worlds in order to improve and adapt learning." (Gueye and Exposito, 2020). Since U4.0 advocates that learning is not limited to classroom anymore, Kulik et al. (2020) allege, offering online and traditional classes to facilitate blended learning is suggested in such an environment. Through various means of learning, students are expected to form personal pathways to accomplish as they are in the center of the higher education ecosystem (Göker, 2019). As part of teaching and learning environment, teaching methodology is also an important indicator of quality and instructor's use of a variety of teaching methods contributes to student learning (Dicker et al., 2019). Therefore, instructors need to have necessary abilities and training to offer quality education to the students of the 21st century. While teaching and learning can take many different forms in line with the needs, preferences and learning styles of the students, there needs to be adjustments in testing and evaluation as well. In parallel with the flexibility in the teaching and learning environment and personalisation of learning experiences, Demir et al. (2019) suggest, along with standardized exams, alternative assessment and evaluation methods need to be used in education program 4.0 so as to respond to the needs of the students while preparing them for the 21st century workplace.

The European Universities Initiative

The significance of education has always been a concern for the promotion of European integration and therefore has been the subject of many initiatives of educational nature, the EUI being one form of these attempts (Frame and Curyło, 2022). "European Universities are ambitious transnational alliances of higher education institutions developing long-term structural and strategic cooperation" (European Commission, 2020). The first call for the EUI was made in 2018 as part of Erasmus+ program. The first EUAs were selected by the European Commission in 2019 with participation of 17 EUAs. The results of the following call where 24 new alliances were selected were announced in 2020 and there was a roll-out phase in July 2022 (European Commission, 2020). The selected alliances were each awarded 5 million euros by means of the Erasmus+ programme (Maassen et al., 2022). 30 new alliances joined the already existing ones as a result of the third call in 2023 (European Commission, 2023). The EUIs offer a variety of added benefits to achieve funding by EU for collaborative education and research work carried out within the alliance (Stensaker et al., 2023).

The EUAs are generally established on former cooperation between universities and constitute the basic modes of new networks that are in the future to turn into European Universities

(Charret and Chankseliani, 2022). Therefore, previous connections and partnerships between involved universities comprise essential pillars of alliance structures (Stensaker et al., 2023). Additionally, the universities participating in alliances are usually similar in that they demonstrate such profiles as technical, comprehensive professional or research universities (Maassen et al., 2022). Even though research, innovation, innovative education and knowledge transfer are promoted in alliances, these are realized through implementation of different models leading to good practices, some of which can be counted as communities and community credentials (EELISA), open labs and free interdisciplinary courses for students (CIVIS), student forum and star system (YUFE), smart campus and buddy system (CONEXUS), alliance academy and alliance café (ARQUS) (Arnaldo Valdes and Gomez Comendador, 2022).

EUIs are “typically discussed as the European Commission’s ‘flagship’ policy with respect to higher education” (Brooks and Rensimer, 2023, p. 5). Promoting European values along with multiculturalism and multilingualism to facilitate collaboration going beyond countries and increasing competitiveness and quality of European universities are the objectives defined in the calls for alliances (European Commission, 2018). Putting the students in the center of the learning process and employing a challenge-based approach, free mobility is promoted between members of the alliances (Hartzell et al., 2023). EUI is also effective in supporting universities for a more efficient communication by means of exchanging knowledge and good practices (Cino Pagliarello, 2022). The rationale behind the EUI is to expand the kinds and layers of collaboration among partner institutions and to turn this collaborative activity into an ordinary circumstance all through the university experience (Frame and Curyło, 2022). The initiative is not considered a regular project with specifications that are previously identified but is expected to function as a continuing series of actions (Charret and Chankseliani, 2022, p. 38). As put by Arnaldo Valdes and Gomez Comendador (2022, p. 3), the EUIs focus on creating:

A new generation of Europeans who are creative and capable of cooperating, beyond languages, borders, and disciplines, to face the great social challenges and lack of capacities that Europe faces to create a European Education Area. This will allow students to graduate by combining study periods in various EU countries and will contribute to the international competitiveness of European Universities.

Since the EUI is a new formation dating back to 2019 with the commencement of the first alliances and still in the development phase, it is not surprising that there is limited scholarly focus on this particular topic. The already existing publications are mainly reports by the European Commission, newspaper articles concentrating on different aspects of the initiative and articles discussing university alliances before official establishment of the EUI. As for scientific publications, there are studies focusing on the formation and characteristics of EUAs (Gunn, 2020), conceptual and empirical analysis of the way alliances build universities of the future as defined by the European Commission (Charret and Chankseliani, 2022), assessment of major gains and difficulties faced by the alliances (Craciun et al., 2023), analysis of whether

the balance between inclusiveness and excellence has been achieved within the alliances (Lambrechts et al., 2023), and analysis of potential perils and benefits that might be experienced by alliances (Maassen et al., 2022). Owing to the novelty of the topic, the studies are mainly of qualitative nature and, to the knowledge of the researcher, there is no single study conducted in quantitative design collecting data from academics employed in different universities of a particular EUA whose members are located in different parts of Europe. Also, no existing study discusses whether or the extent to which academic practices of EUAs are aligned with the indicators specified as good practice in the context of U4.0. To this end, this study aims to explore the perceptions of academics in an EUA concerning the extent to which already existing academic practices align with good practice indicators defined for HE4.0 and pursue responses to the following research questions:

1. What are the good practice indicators of U4.0 from an academic perspective?
2. Are there any statistically meaningful differences between perceptions of academics from universities involved in an EUI concerning the good practice indicators of U4.0?
3. What are the academics’ perceptions toward implementation of activities that are specified as good practice indicators of U4.0 in their own institutions as a member of an EUI?

Materials and methods

Data collection and analysis

The research was conducted employing a comparative survey design (Karasar, 2006) in which, due to lack of an existing data collection instrument, a statistically valid and reliable instrument was devised by the researcher to showcase good practice indicators of U4.0 from an academic perspective for data collection. During the development of the data collection tool, a comprehensive literature review was done, a pilot study was conducted and expert opinion and advice were sought. Initially, the item pool was formed based on the literature review and took form in accordance with relevant statistical analyses and expert opinion and advice. KMO and Bartlett’s tests were executed to test factorability and KMO was found $0.902 > 0.60$ and Bartlett was also found highly meaningful ($p < 0.001$), which led to the conclusion that data was appropriate for factor analysis. As a result of the factor analysis conducted, seven items were eliminated and the final scale comprised 62 items apart from the demographics section under three factors. The factors and total variance ratio explained by these factors are displayed in Table 1.

Accordingly, the items were analyzed and named as follows: *Educational Offerings*, *Student Skills and Competencies* and *Teaching and Learning Environment*. After completion of validity analyses, internal consistency coefficient was calculated for reliability analysis. Creswell (2012) defines Cronbach alpha as a measure to test reliability, particularly internal consistency. As 0.60 is accepted as the threshold for reliability and as all the alpha values in the scale were calculated over 0.60, no items were eliminated at this stage. The Cronbach alpha value of the scale was calculated as 0.97; 0.95 for *Educational Offerings*, 0.94 for *Student Skills and Competencies*, and 0.89 for *Teaching and*

TABLE 1 Factors and the total variance explained.

Comp.	Total variance explained								
	Initial eigenvalues			Extraction sums of squared loadings			Rotation sums of squared loadings		
	Total	% of variance	Cumulative %	Total	% of variance	Cumulative %	Total	% of variance	Cumulative %
1	23.717	38.254	38.254	23.717	38.254	38.254	11.674	18.829	18.829
2	3.217	5.189	43.442	3.217	5.189	43.442	10.155	16.379	35.208
3	2.579	4.159	47.602	2.579	4.159	47.602	7.684	12.393	47.602
4	2.404	3.877	51.479						
5	1.977	3.188	54.667						
6	1.689	2.724	57.390						
7	1.618	2.609	59.999						
.....						
61	0.047	0.076	99.926						
62	0.046	0.074	100.000						

Extraction method: principal component analysis.

Learning Environment. These values indicate that the scale devised as the data collection instrument as part of the study could be utilized for data collection as a valid and reliable instrument.

related to 21st century higher education practices, and 53.4% of the academics were actively involved in the activities of the respective EUA to which their university belonged.

Context and participants

The scale was administered in the context of an EUA, which comprises the top education and research institutions in their respective countries representing engineering, science and humanities education. The EUA aims to transform education and research in the European Higher Education Area through innovative approaches that will contribute to solution of global challenges in the long-run, which constitutes one of the essential pillars of U4.0.

In total, 161 academics employed in nine different European Universities as members of the EUA participated in the study. The scale was administered online through an online data collection platform and the participants were asked to provide written informed consent to voluntarily participate in the study. Demographic information about the study group is presented in Table 2.

Academics working in two universities from France, two universities from Italy, one university from Spain, one from Hungary, one from Türkiye, one from Romania and one university from Germany, which are all members of the EUA participated in the study and the biggest percentage of participants was from the Spanish University (34.8%). The ages of academics ranged between 27 and 79 and female academics made up of 44.1% of the whole population. Associate professors constituted the biggest percentage as 36.6% and the experience levels of academics ranged between 1 and 56 years. As for the field of study, a majority of academics were from the field of engineering and technology. 49.1% of the participants had an administrative role in their institution, 55.3% of them participated in quality management activities of their respective institutions, 55.9% received education and/or training

Findings

To identify statistically meaningful differences between perceptions of academics from universities involved in an EUI concerning the good practice indicators of U4.0, data was analyzed by means of SPSS 24.0 and comparative analyses of scale scores were conducted in accordance with dependent variables in line with the objectives of the study. Accordingly, Kruskal Wallis-H, Mann Whitney-U, One-Way ANOVA, Independent Samples *T* tests and Pearson correlation tests were performed.

Relevant statistical analyses demonstrated that academics perceptions and levels of awareness differ significantly according to gender of participants. Table 3 shows how scale scores differ according to gender along the sub-dimensions.

It can be concluded that female academics have higher awareness of Educational Offerings ($t = 3.27; p = 0.01$) including such indicators as *Curriculum is designed as a dynamic system; Ethical values are emphasized in curriculum design, Student Skills and Competencies* ($U = 2,071.00; p < 0.001$) including such indicators as *Students are equipped with project management skills; Students are equipped with knowledge of economics and Teaching and Learning Environment* ($t = 2.57; p = 0.011$) including such indicators as *Students are offered opportunities to engage in volunteer projects; Students are offered multi-disciplinary study opportunities* and the total score of the scale ($U = 2,162.50; p < 0.001$) within the scope of HE4.0 practices implemented at alliance universities.

Regarding active involvement in the EUA activities, it was found that academics who are actively involved in alliance activities have more awareness toward HE4.0 practices in terms of Educational Offerings ($t = -2.31; p = 0.022$), which includes such indicators as *Troubleshooting technologies are emphasized in*

TABLE 2 Demographic information of the study group.

Variables	Groups	f	%
University	France 1	6	3.7
	Türkiye	54	33.5
	Italy 1	4	2.5
	France 2	11	6.8
	Spain	56	34.8
	Hungary	22	13.7
	Romania	3	1.9
	Italy 2	2	1.2
	Germany	3	1.9
Age	20–30 years	13	8.1
	31–40 years	34	21.1
	41–50 years	54	33.5
	51–60 years	47	29.2
	61+ years	13	8.1
Gender	Female	71	44.1
	Male	90	55.9
Academic title	Professor	44	27.3
	Associate professor	59	36.6
	Assistant professor	23	14.3
	Lecturer doctor	14	8.7
	Lecturer	12	7.5
	Research assistant	9	5.6
Experience	1–10 years	48	29.8
	11–20 years	55	34.2
	21–30 years	42	26.1
	30+ years	16	9.9
Field of study	Natural sciences	14	8.7
	Engineering and technology	103	64.0
	Agricultural sciences	9	5.6
	Social sciences and humanities	35	21.7
Administrative role	No	82	50.9
	Yes	79	49.1
Participation in QM activities	No	72	44.7
	Yes	89	55.3
21st century higher education activities	No	71	44.1
	Yes	90	55.9
Active involvement in the alliance	No	75	46.6
	Yes	86	53.4

curriculum design, Education offered to students is tailored for their needs; Teaching and Learning Environment ($t = -2.19; p = 0.030$), which is presented in the scale through such items as *Students are*

given the chance to grasp theoretical knowledge outside the classroom and practice F2F inside the classroom, Students are provided with opportunities to synthesize information from a variety of topics and the total mean score of the scale ($t = -2.17; p = 0.032$). Based on the findings, involvement in European University activities seems to make a positive contribution to increasing awareness regarding ideal higher education practices in new generation universities in the era of I4.0. Table 4 demonstrates how scale scores differ according to active involvement in the EUA activities along the sub-dimensions.

In addition to the comparative statistical analyses, the responses were analyzed based on individual items included in the scale to determine academics' perceptions toward implementation of activities that are specified as good practice indicators of U4.0 in their own institutions as a member of an EUI. The processes and practices included in the sub-dimensions of the scale showcasing the highest priorities by academics in the EUI universities were categorized accordingly as indicated in Table 5: Student Skills and Competencies [*Students are equipped with technical skills*] ($\bar{x} = 4.16$); Teaching and Learning Environment [*Students are provided with opportunities to work in teams*] ($\bar{x} = 4.12$); Educational Offerings [*Education offered to students is knowledge and skills-based*] ($\bar{x} = 4.09$); and Student Skills and Competencies [*Students are equipped with teamwork skills*] ($\bar{x} = 3.93$).

As for the practices that need to be attached more emphasis in the scope of U4.0, the analyses revealed the following: Teaching and Learning Environment [*A considerable number of scientific and educational practices take place in virtual environments*] ($\bar{x} = 2.66$); Student Skills and Competencies [*Students are equipped with knowledge of governance*] ($\bar{x} = 2.72$); Student Skills and Competencies [*Students are equipped with knowledge of global policies and laws*] ($\bar{x} = 2.76$); Educational Offerings [*Students are offered micro-credentials to enhance their employability prospects*] ($\bar{x} = 2.83$). The good practice indicators that need to be accentuated are showcased in the Table 6.

The findings of the research were discussed in accordance with the related literature.

Discussion

As mentioned earlier, research conducted in the area of EUI is limited as the commencement of these activities dates back to only 2019. The research that has been conducted so far mainly comprises reports by the European Commission focusing on particular aspects of this initiative, reviews of open-source materials and interviews. Therefore, the findings of this study function as descriptive rather than comparison of findings with previous studies conducted in this particular area.

It is a fact that the future of education, work and gender will be constructed by industrial revolution 4.0 (Ramirez, 2018). Accordingly, one of the concentrations of the European Research Area is to achieve gender equality and gender integration, taking into consideration the needs and interests of men and women (Weitgruber, 2020). Gender equality is also one of the United Nations Sustainable Development Goals as stated in "By 2030, eliminate gender disparities in education and ensure equal access

TABLE 3 Comparative analysis of scale scores according to gender.

Sub-scale	Groups	n	\bar{x}	sd	Test statistics	Cohen's d
Educational offerings	Female	71	3.57	0.67	3.27 ^{*a}	0.536
	Male	90	3.22	0.64		
Student skills and competencies	Female	71	3.61	0.67	2,071.00 ^{*b}	0.633
	Male	90	3.26	0.66		
Teaching and learning environment	Female	71	3.48	0.59	2.57 ^{*a}	0.420
	Male	90	3.23	0.60		
Total point	Female	71	3.56	0.59	2,162.50 ^{*b}	0.577
	Male	90	3.25	0.59		

*p < 0.05, ^aIndependent sample t test, ^bMann-Whitney U test.

TABLE 4 Comparative analysis of scale scores according to active involvement in the EUA activities.

Sub-scale	Groups	n	\bar{x}	sd	t	Cohen's d
Educational offerings	No	75	3.25	0.67	-2.31 [*]	0.37
	Yes	86	3.49	0.66		
Student skills and competencies	No	75	3.33	0.59	-1.61	0.25
	Yes	86	3.50	0.74		
Teaching and learning environment	No	75	3.23	0.62	-2.19 [*]	0.35
	Yes	86	3.44	0.58		
Total point	No	75	3.27	0.58	-2.17 [*]	0.34
	Yes	86	3.48	0.62		

*p > 0.05.

TABLE 5 University 4.0 good practice indicators prioritized by EUI universities.

	N	Minimum	Maximum	Mean	Std. deviation
Student skills and competencies [students are equipped with technical skills]	161.00	1.00	5.00	4.16	0.84
Teaching and learning environment [students are provided with opportunities to work in teams]	161.00	1.00	5.00	4.12	0.91
Educational offerings [education offered to students is knowledge and skills-based]	161.00	2.00	5.00	4.09	0.78
Student skills and competencies [students are equipped with teamwork skills]	161.00	1.00	5.00	3.93	0.90

TABLE 6 University 4.0 good practice indicators requiring more emphasis.

	N	Minimum	Maximum	Mean	Std. deviation
Educational offerings [students are offered micro-credentials to enhance their employability prospects]	161.00	1.00	5.00	2.83	1.10
Student skills and competencies [students are equipped with knowledge of global policies and laws]	161.00	1.00	5.00	2.76	1.03
Student skills and competencies [Students are equipped with knowledge of governance]	161.00	1.00	5.00	2.72	0.96
Teaching and learning environment [a considerable number of scientific and educational practices take place in virtual environments]	161.00	1.00	5.00	2.66	1.08

to all levels of education and vocational training” (United Nations, 2015, p. 21).

The present research demonstrated that female academics seem to have a higher awareness of and more sensitivity toward activities related to U4.0, which is in parallel with the mention of gender in the Erasmus call for the EUI in the form of “...to

promote the inclusion, access, participation and completion of under-represented groups and people with fewer opportunities, as well as support for gender equality in higher education” [European Education and Culture Executive Agency (EACEA), 2021]. Therefore, from the beginning, gender has been one of the core elements and particular emphasis has been attached to gender

in the EUI, which is usually contained in “fostering inclusiveness and diversity” as in EELISA; “...promotes equity, inclusion and diversity while pledging to eliminate barriers” as in FilmEU; “...we commit ourselves fully to gender equality, non-discrimination and social equity” as in Civis and “full integration of people with disabilities and members of minority groups, and equality between women and men prevail” as in SEA-EU (Hartzell et al., 2023). For example, one of the objectives shared by the alliances is to realize institutional change through such initiatives as gender equality plans (Arnaldo Valdes and Gomez Comendador, 2022). It seems that all these activities have contributed to increasing the awareness of women academics concerning good practice indicators in the context of U4.0.

While Taib et al. (2023) found no differences in the perceptions of male and female academics toward education 4.0, Porubčinová and Novotná (2020) emphasized that women’s social skills present an advantage in the digital age when compared to men, which becomes even more effective with the integration of advanced digital literacy. Also, instructional and transformational leadership skills facilitate adaptation to I4.0 as reflected in higher education practices (Chuang and Eversole, 2022). The study conducted by Shaked et al. (2019) revealed that women demonstrate higher levels of instructional knowledge and experience and are better in adopting and implementing transformational measures (Barbuto et al., 2007), which may also be influencing factors that account for the difference in women academics’ higher levels of awareness toward U4.0 transformation in the current study.

Another important finding of the research was related to positive influence of active involvement in the activities by the EUAs. Involvement in EUI, needless to say, brings many benefits and makes a positive contribution to awareness and understanding of processes and practices identified as good practices within the scope of U4.0. As put by Craciun et al. (2023, p. 38):

HEIs perceive their participation in an EUA as an opportunity to increase the attractiveness and quality of their educational offerings and improve their ability to engage in transnational collaboration. Important mechanisms for achieving these goals are mutual learning, sharing best practices, and involvement in new educational approaches.

Furthermore, within the scope of alliance activities, involvement in policy networks and communication going beyond countries contributes to dealing with issues influencing higher education institutions together and a majority of individuals involved in alliances share positive attitudes toward being a member of a university alliance (Cino Pagliarello, 2022). This finding takes us to the conclusion that being actively involved in activities conducted by the EUAs is an effective way of increasing awareness toward good practice indicators of U4.0.

Concerning the analysis of individual items in the scale reflecting academics’ perceptions toward implementation of activities that are specified as good practice indicators of U4.0 in their own institutions, the practice receiving the highest score is *Students are equipped with technical skills*, which are hard skills that can be developed by means of practice and formal classroom teaching in a specific domain (Chiu et al., 2016). The finding is in parallel with the literature in that lifelong learning formats as required in the scope of U4.0 are anticipated to put emphasis on

developing technical skills pertaining to a specific area of expertise (Birtwistle and Wagenaar, 2020) because as part of continuous improvement within the framework of U4.0, improvement of conceptual and technical skills during the period of students’ study period at university is considered one of the quality indicators (Latif et al., 2019). This is particularly important as technical skills are also one of the most important indicators of decision-making skills and integration of decision making in technical skills is regarded as an efficient way so as to accomplish sustainable development (Alshawi et al., 2023), which is another significant area of knowledge that needs to be focused on as part of U4.0 practices.

It is a fact that technical universities offer their students good quality education to equip them with technical skills and they are usually successful in that. While there is too much focus on technical skills, usually the syllabi are so packed that there is no room for soft skills or social skills that will help students achieve in their professional lives. As put by Neaga (2019, p. 3–4), “21st century skills encompass not only technical/engineering and domain-specific knowledge and expertise, but also domain-independent meta-skills such as critical thinking, creativity, communication, and cross-cultural collaboration, and moreover dealing with the complexity of future industrial issues of Industry 4.0.” Therefore, there needs to be a shift of focus toward development of soft skills in the curricula of U4.0.

Miranda et al. (2021) identify five transversal competencies as key to HE4.0, which are communication, cooperation, collaboration through teamwork, critical thinking, creativity and innovation. Another important finding of the present research is that the students are equipped with teamwork skills and they are offered opportunities to work in teams, which is considered one of the most important key competencies articulated in the scope of U4.0. It is a fact that “Teamwork skills (working with others) enable employees to develop new ideas and solve every situation in real work life” (Hadiyanto et al., 2022, p. 79); therefore, teaching of soft skills such as teamwork equips graduates with the skills necessary for 21st century workplace (Orr, 2020). Within this framework, universities are expected to promote teamwork and interpersonal skills to facilitate graduates’ transition to withstanding challenges in daily life, boosting effectiveness and innovation (Chitkara et al., 2020), which can be achieved through encouragement of and emphasis on teamwork during educational activities.

The outcomes of the research suggest that a majority of consortium universities in the scope of the EUI offer education to students that is knowledge and skills based, which is in line with the knowledge-based view (KBV) as one of the key theoretical perspectives on rationales to form strategic alliances, suggesting that knowledge should be pursued as a strategic source (Fehrenbach and Huisman, 2022). As known, there has been substantial emphasis on the construction of a knowledge-based society across Europe by the European Commission. Accordingly, publications have been made about the Lisbon Treaty throughout the years to attract attention to the very topic (Birtwistle and Wagenaar, 2020). Through creation of a knowledge-based society, innovations can be made by means of shared knowledge and creativity especially in such times that are surrounded by uncertainty and global mobility (Buasuwan, 2018). Constructing and maintaining a knowledge-based society is a must in the era we are experiencing currently to contribute to transformation of knowledge, which is then to be utilized as a critical source to transform the society as a whole.

According to the report on the future of jobs which was carried out by the World Economic Forum in 2018, the ten trending skills in parallel with fundamental skills and competencies to be confronted in I4.0 as mentioned by [Aprilisa \(2020\)](#) are analytical thinking and innovation, active learning and learning strategies, creativity, originality and initiative, technology design and programming, critical thinking and analysis, complex problem solving, leadership and social influence, emotional intelligence, reasoning, problem solving and ideation, systems analysis and evaluation. In the digital society, which emerged as a response to I4.0 environment, “Advancement of digital and/or online education supported by an Education 4.0 framework will facilitate the development of skills and building graduates’ competences for contemporary industry based on I4.0” ([Neaga, 2019](#), p. 1). Therefore, skills-based education needs to be implemented and strategies must be adopted to construct skills accommodating educational objectives ([Latif et al., 2019](#)). Whatever strategy is embraced, it is of utmost importance to match the educational objectives with the needs of the industry analyzing the students’ needs based on feedback from all stakeholders of the education process to be able to comparatively see the most relevant knowledge and skills.

In the new education environment responding to the requirements of I4.0, technology integration into teaching and learning needs to be remodeled to accomplish smart allocation and cooperation of both physical and virtual components in the provision of education ([Gueye and Exposito, 2020](#); [Sulkowski et al., 2021](#)) enabling flexible and personalized learning experiences for students. HE4.0 supports the following forms of course delivery: face-to-face, distance and hybrid, which are grounded in active learning, flexible digital models and techniques like flipped classroom, respectively ([Miranda et al., 2021](#)). In the scope of flexible digital models to foster virtual education practices, [Demir \(2018\)](#) suggests that “new educational approaches such as openness principle (like MIT-Open), personalization (like iTunes University-Apple), informal education programs (Courseera), space and time independence (like Khan Academy), virtual reality (VR) are supported by new educational technologies such as interactive books, videos and animations” (p. 150). These new models are expected to contribute to formation of a virtual university where a large volume of educational activities occur in digital environments ([Kulik et al., 2020](#)), which seems to require more emphasis as revealed by the present research.

As digital literacy capabilities remain at the forefront in accordance with the needs of the digital society, professors and students should have a good command of, for example, “Big data analysis, artificial intelligence applications, cybersecurity, Internet of Things, robotics solutions, I4.0, virtual reality, and augmented reality” ([Toprak et al., 2020](#), p. 172) via such means as virtual reality, google assistant and Siri ([Falaq, 2020](#)). Only through this way, the students will have a competitive advantage to succeed in their professional lives considering the priorities of new generation employees. Therefore, [Chitkara et al. \(2020\)](#) assert:

to accommodate students in the best way possible, traditional classroom teaching should be left behind through virtual and self-paced learning, the adjustability to which is

catered by e-learning. The personalized learning experience brought by this situation will contribute to attraction of students’ interest as well as improving their performance. As ideal practices, it will lay the groundwork for obtaining theoretical knowledge outside of the classroom leaving room for implementation of practical knowledge face to face.

The current research also demonstrated that there needs to be more focus on teaching governance, which is regarded as one of the essential areas of knowledge to equip the students with during the 4th industrial era ([Kankaew, 2019](#)). This may be due to insufficiency of awareness about this particular topic. According to [Council of Europe \(2023\)](#), knowledge of governance is knowledge of efficiency and effectiveness, transparency, ethical conduct, human rights and accountability, openness to change, long-term orientation and sustainability, all of which help to contribute to students into becoming good citizens, which falls under the responsibility of universities. Encompassing this many traits required for new generation workplaces, it seems evident that governance and equipping the students with its very knowledge should be one of the main components of U4.0 curricula.

As known, together with the rate of globalization, global citizenship, which implies having an active role in community and working with others to make our planet fairer, more sustainable and more peaceful, has become more widespread as a consequence of transition to I4.0. In this scope, as asserted by [Madaliyeva et al.](#), commenced by the United Nations, global citizenship education program focuses on education and training of an individual as a world citizen and as a representative of universal community bounded by ethics of social responsibility ([Madaliyeva et al., 2020](#)). Innovating education practices as well as catering for the needs of the society for raising competent graduates and global citizens also fall under the responsibility of universities ([Falaq, 2020](#)). Therefore, it is of prime importance to increase students’ awareness about global policies and laws so that they are raised at an international level education system, which will help universities fulfill their responsibilities in raising world citizens taking active roles in the transformation of societies.

Another important finding of the research was the insufficient focus on implementation of micro-credentials, which are defined by [Isaacs \(2020\)](#) as small and tailored learning experiences that lead to 3-5 credits in ECTS. Micro-credentials are anticipated to construct new technical skills and knowledge pertaining to a specific area of expertise, also contributing to skills and competencies of professionals in the context of lifelong learning ([Birtwistle and Wagenaar, 2020](#)). They bring many advantages including but not limited to acquiring knowledge and skills in a flexible way so that individuals are more prepared for potential changes in an environment that changes very fast and can lead to added value by functioning as complementary to already existing qualifications ([Council of the European Union, 2022](#)). Still, “lack of understanding of micro-credentials, low standardization, low recognition and quality issues, limited stackability and transferability, mistrust in online education and testing, difficulty of teaching soft skills, accessibility and monetary issues, slow response rate and limited resources of universities are listed among the challenges for adopting micro-credentials.” ([Özbek, 2019](#)).

Some of these disadvantages also apply to the EUI. Within this framework, there does not seem to be a consensus among the EUI consortia about awarding of micro-credentials. They are generally awarded for extracurricular activities in the form of extra ECTS credits. However, a degree has not yet been created based on micro-credentials. There are also many legal issues related with stackability of micro-credentials, which hinders micro-credentials from accommodating interdisciplinarity (Craciun et al., 2023). It is evident that prominence is required to eliminate potential detriments of micro-credentials to reveal their added-value as a joint practice across EUAs.

Conclusion

This study proposes a framework of good practice indicators of U4.0 from an academic perspective under the themes of *Educational Offerings, Student Skills and Competencies* and *Teaching and Learning Environment* with input from academics employed in different universities across Europe forming the consortium of an EUA. The study originated from the commonalities between the main principles of U4.0 from an academic perspective and objectives of the EUI. Concerning the differences between academics' perceptions toward good practice indicators of U4.0, the study demonstrated that women academics have higher awareness of good practice indicators of U4.0 and being actively involved in the EUA activities makes a positive contribution to comprehension and awareness of what is accepted as good practice in the scope of U4.0. With regard to academics' perceptions about the extent to which good practice indicators are implemented as part of their institutional practices, it was revealed as a result of the study that a majority of universities as members of the EUA equip their students with technical skills, provide opportunities for their students to work in teams and improve their teamwork skills as well as offering knowledge and skills-based education to their students as part of U4.0 good practice indicators. However, more emphasis is needed on offering scientific and educational practices in virtual environments, equipping students with knowledge of governance, global policies and laws and offering micro-credentials to enhance the students' employability prospects.

While the match between employers' needs and preferences and graduate attributes have gained this much prominence in this increasingly globalized world, it is evident that this work will contribute to equipping the students with necessary knowledge, skills and competencies to achieve in the 21st century workplace. Furthermore, in line with the rise of EUAs due to their focus on the transformation of higher education practices toward becoming the universities of the future, it is believed that this study will help improve practices in the EUAs by offering good practice indicators that could function as a framework while planning, organizing and conducting educational practices in the 4th industrial era.

Among the limitations of the study could be counted the collection of data from a single EUA comprising members from different parts of Europe and analysis of data based on perceptions of academics employed in related member universities. Therefore, the findings of this study cannot be generalized to the whole population of EUAs. Future work, thus, could benefit from implementation of the statistically valid and reliable data collection instrument devised in the present research in other EUAs to

explore their perceptions concerning good practice indicators of *Educational Offerings, Student Skills and Competencies* and *Teaching and Learning Environment* of U4.0. The components of U4.0 could also be applicable to universities outside of the initiative so that comparative analyses could be made to contribute to generalization of results and dissemination of good practice indicators as identified in the scope of U4.0.

Data availability statement

The datasets presented in this article are not readily available because of privacy reasons. Requests to access the datasets should be directed to NÜ, ulkern@itu.edu.tr.

Ethics statement

The studies involving humans were approved by Institutional Review Board of the Researcher. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

NÜ: Writing – original draft, Writing – review & editing.

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The author declares that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Generative AI statement

The author(s) declare that no Gen AI was used in the creation of this manuscript.

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