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Serbian Journal of Management 21 (1) (2026) 127 - 145

Serbian Journal of Management

HIGHER EDUCATION IN LIGHT OF INDUSTRY 5.0: SERVQUAL-SEM QUALITY DIMENSIONS

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(Received 15 January 2025; accepted 27 February 2025)

Abstract

The Industrial Revolution wheels the development of society, and its transformation reflects the upcoming Industrial Revolution. This led to Industry 5.0 and Society 5.0. in many areas, even in education. Therefore, universities should achieve a high level of service quality to align with new industrial trends where humans are expected to be innovative and collaborative in a shared working environment with new digital technologies. Thus, this paper aims to research the relationship among SERVQUAL quality variables of online higher education (Tangibility, Reliability, Readiness, Assurance and Empathy) and their impact on student perception of Industry 5.0 effects on higher education quality. To achieve this aim, the survey was carried out among 532 university students. Structural Equation Modeling (SEM) shows that all analysed relationships among SERVQUAL variables are confirmed and indicate a positive impact. Furthermore, the influence of the mentioned quality variables on the students' perception of Industry 5.0 effects on higher education quality is also considered. Considering those relationships, Reliability is the only significant variable impacting students' perception of Industry 5.0 effects on higher education quality. These conclusions could be used to develop a framework for quality improvement of online higher education in Industry 5.0, leading to the base for developing new Society 5.0.

Keywords: Industry 5.0, Society 5.0, higher education, SERVQUAL-SEM quality model

1. INTRODUCTION

The fourth industrial revolution (Industry 4.0) has brought a revolutionised increment in manufacturing and production systems' operational efficiency, and many new business models, services, and products have been developed (Nayar & Koul, 2020; Mourtzis et al., 2022). On the other side, this digital system/machine-oriented era opened

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DOI: 10.5937/sjm21-56043

significant space for thinking about the sustainability of achievements efficiency since incorporating modern technologies into processes affected the workforce (Zizic et al., 2022). Accordingly, many efforts have begun to be put into initiatives toward designing and developing the human-centred aspect of systems, tools, and technologies (Leng et al., 2022; Mourtzis et al., 2022). It is recognised that the vital for sustainable success is to achieve people's capability of adapting to new working conditions, learning, and sharing knowledge (Lepore et al., 2021). Consequently, the fifth industrial revolution (Industry 5.0) concept, as a solution where humans and machines cooperate in a mutual working environment, leads to the generation of a new society, Society 5.0. As such, Industry 5.0 has arisen to overcome the challenges in Industry 4.0 (Mourtzis, 2021). Therefore, sustainability, resilience, and human orientation will be the core focus of Industry 5.0 (Zizic et al., 2022). Industry 5.0 concept integrates the workforce with intelligent systems to upgrade process efficiency by utilising human creativity and brainpower (Nahavandi, 2019). To enable sustainable growth in all societal aspects (e.g., health, education, economy), humans have to have positive relationships with new technologies (Ferreira & Serpa, 2018). Hence, Society 5.0 strives to put human beings at the nucleus of innovation to improve quality of life, social responsibility, and sustainability (Carayannis & Morawska-Jancelewicz, 2022).

Society 5.0's revolutionising perspective corresponds to the objectives of the United Nations Sustainable Development Goals, where the main implication for universities' transformations is recognised (Carayannis & Morawska-Jancelewicz, 2022). Past years fastened the digitalisation process of education worldwide so that important conclusions could be derived from the gained experience. The period of COVID-19 has shown many advantages of digital transformation within the education system (Mileva et al., 2022). On the other hand, the overall online higher education quality should be thoroughly considered to facilitate Society 5.0 development. One of the comprehensive and most discussed approaches to service quality assessment in education is the SERVQUAL model (Sultan & Wong, 2012). Through such an approach, higher education quality in the online environment could be evaluated on the level of specific quality features, observing the relationship between customers' expectations and their perception of each feature's quality. In that way, the overall service quality and, thus, the roadmap for quality improvement could be designed for online higher education in the era of Industry 5.0.

In the current development of higher education quality, there is a literature gap in exploring how the new era of Industry 5.0 reflects education and what significant mutual relationships exist among online education quality variables. There is also a research space to use the SERVQUAL-SEM approach to verify such a scheme of quality variables independence in the Industry 5.0 online higher education system. Thus, the paper aims to explore the relationship among SERVQUAL quality variables: Tangibility, Readiness, Reliability, Assurance, and Empathy within online higher education and their impact on student perception of Industry 5.0 effect on higher education quality. The focus is directed not only to new digital technologies and trends but also to human-related valuables of the education system, according to the Industry 5.0

paradigm. In this way, the paper strives to explore an existing quality assessment model, such as SERVQUAL, in the mutual relationship between new industrial trends and Society 5.0.

2. LITERATURE REVIEW

Industry 5.0 is an industrial revolution, relayed on challenges of Industry 4.0 (Stojanović, 2022), that strives to enable sustained human-centric manufacturing systems (Breque et al., 2021). As such, Industry 5.0 is complementing Industry 4.0 by directing focus on the workers who have an important role in the production process, which has been especially recognised during the COVID-19 pandemic (Zizic et al., 2022). The Industry 5.0 concept has appeared as the vision of a future industry that protects the environment and society (Ghobakhloo et al., 2022). Emphasising human-machine interactions, as a result, Industry 5.0 is value-driven rather than process-driven (Verma et al., 2021). The development of Industry 5.0 technologies will not downgrade human value but will rather stress the importance of inter-integration between human and machine intelligence in a collaborative environment (Di Nardo & Yu, 2021). The alliance between the key technological drivers and societal development is established by Industry 5.0 (Jefroy et al., 2022). Industry 5.0, as the socially intelligent factory era, is expected to enhance the focus on human needs when applying advanced technologies in industrial processes (Friedman & Hendry, 2019), thus creating a new Society 5.0.

Society 5.0 is a highly intelligent society based on integrating the workforce with digital technologies (Deguchi et al., 2020). Similarly, Society 5.0 is defined as a "Superintelligent Society", utilising the strengths of the technological progress obtained during the era of Industry 4.0 to upgrade societal aspects (Rojas et al., 2021). The concept "Industry 5.0 - Society 5.0" emphasises the significance of research and innovation to support the industry in its long-term service to humans (Xu et al., 2021). Society 5.0 is a prospective society guided by scientific and technological innovation that creates a human-centred, super-smart, and lean society (Huang et al., 2022). Accordingly, it is argued that humans and society's sustainable development needs more effort from industrial academia and practitioners (Callaghan, 2019; Jefroy et al., 2022). In line with this, universities are called upon to boost knowledge suitable for new technologies and social development since digital transformation opens new prospects for universities, where both universities and societies could significantly benefit from it (Carayannis & Morawska-Jancelewicz, 2022). Lifelong learning and transdisciplinary education are recognised as key strategies for a sustainable future (Broo et al., 2022). Thus, to utilise new opportunities within the Industry 5.0 era, universities need to produce a high level of service quality, which is vital for the development of human capital (Gupta & Kaushik, 2018) and, accordingly, to sustainable industry success.

To ensure a high level of service quality, it is firstly necessary for an online service organisation, such as a university, to be aware of how end-users distinguish and assess online customer services (Parasuraman et al., 2005). Furthermore, since e-learning programs have been dramatically expanding in line with new industrial and societal trends, assessment of

the quality of e-learning has become a critical strategic issue (Arsić et al., 2023; Milošević et al., 2023). One of the approaches that have received the most attention in the literature on educational service quality assessment is the SERVQUAL model (Sultan & Wong, 2012). Parasuraman et al. (1988) outlined five dimensions of service quality on the SERVQUAL scale: "(1) Tangibles: physical facilities, equipment, and appearance of personnel; (2) Reliability: the ability to perform the promised service dependably and accurately; (3) Responsiveness: willingness to help customers and provide prompt service; (4) Assurance: knowledge, and courtesy of employees and their ability to inspire trust and confidence; (5) Empathy: caring, individualised attention the firm provides its customers".

Development of Industry 5.0 and Society 5.0 has required knowledge and technologies for the management of both the industry and academia, which are interested in transforming educational programs to include new concepts but also tangibles like digital learning platforms and equipment (Catal & Tekinerdogan, 2019). Therefore, digital tangibles are an essential prerequisite for online education success (Kazimirov, 2018). These elements include lecturers' equipment in the online education model (Kazimirov, 2018). The equipment, i.e. the tangible elements of online teaching, is constantly being developed, which further emphasises its necessity (Maddikunta et al., 2022). Without it, the online education system would not be able to function (Catal & Tekinerdogan, 2019; Maddikunta et al., 2022). Furthermore, the purpose of these tangible elements, such as equipment, instruments, and environment, is to ensure the visibility of the participants of the online educational process, as well as the materials used for ergonomics in that process (PDF, PowerPoint, and Word content, guidelines how to use, handout, and chat) (Moldovan, 2019; Catal & Tekinerdogan, 2019; Kuts & Lavrentieva, 2022). Therefore, these elements of education are needed to complete the online learning process successfully. Moreover, they are indicators of the system's readiness for this type of learning (Kuts & Lavrentieva, 2022). Accordingly, Hypothesis 1 is proposed:

H1. Tangible elements positively impact readiness for online higher education.

Indicators of readiness and eagerness for online education can be the lecturer's commitment to comply with the defined rules, the lecturer's willingness and competency to overcome potential problems in online education and its availability (Mian et al., 2020). Each of these elements needs to be at the appropriate level of development and application (Mian et al., 2020). If there is lecturer readiness and willingness to work with students within Industry 5.0, then the reliability of such an education system could be achieved (Maddikunta et al., 2022). Reliability in online higher education is reflected in the respect for plans and ways of educational processes and taking exams, the dedication and perseverance of lecturers in education and communication with students (Catal & Tekinerdogan, 2019). Consequently, the second hypothesis is developed:

H2. Readiness positively impacts the reliability of online higher education.

Furthermore, the level of online education readiness may reflect the assurance in online

education (Agarwal et al., 2021). The assurance in online education can be understood as the trust that lecturers instil in students with their competence, knowledge and experience, as well as the security that students feel (Udo et al., 2011; Main et al., 2020). Some research results (e.g. Gudiño Paredes et al., 2021; Arnold, 2022) released an important effect of distance examing regarding personal academic morality. Feelings of responsibility and awareness of being monitored are recognised as more dominant causes of student motivation than their ethical values (Gudiño Paredes et al., 2021). These criteria are very important in today's virtual environment in all areas and, consequently, in online education (Maddikunta et al., 2022). Therefore, the third hypothesis reads:

H3. Readiness positively impacts the assurance in online higher education.

The empathy issue should be given special attention in education within Industry 5.0. Empathy in online education means giving attention to each student in online work by respecting the agreed time of classes or consultations and understanding the specific needs of students in a digital environment (Longo et al., 2020; Sumi & Kabir, 2021). Empathy is an extremely important aspect of traditional education, but it can be somewhat facilitated by the direct contact between lecturer and student (Bakir & Dahlan, 2022). However, this aspect is quite delicate in the online environment, especially when it is challenging to build a conventional relationship at a distance (Mazur & Walczyna, 2022). Hence, this aspect deserves considerable attention. Also, there is a question of what can lead to the development of an extensive level of empathy in Industry 5.0 education. Therefore, the following hypothesis is stated:

H4. Readiness positively impacts empathy in online higher education.

Initially, reliability is seen as the ability of an organisation to perform the promised service accurately, on time, and dependably (Parasuraman et al., 1988; Tumsekcali et al., 2021) or to provide the implementation of proposed curricula (Milojević & Radosavljevic, 2019). In higher education, it can be related to resolving student problems, complaints, and requests (Goumairi et al., 2020). However, it can be very challenging to investigate whether reliability in an online environment affects the pretensions towards the coming industrial era, considering that there is still no relevant research and experience dealing with this relationship in higher education. Nevertheless, Naveed et al. (2021) proved that increased reliability motivates students to use the online education system. Moreover, this study shows that the online education system's reliability increases satisfaction and influences its future usage among university students. Thus, the following hypothesis is proposed:

H5. Reliability impacts students' perception of Industry 5.0 effects on online higher education quality.

According to Udo et al. (2011, p. 1274), assurance is "an indication of the knowledge and courtesy of employees and their ability to inspire trust and confidence". It also includes the safety and security of students' personal information as essential issues in every university (Pham et al., 2019). Furthermore, the assurance is directly related

to the willingness of the students who participate in online learning to gain much experience in the field, get well-prepared lectures and have a genuine interest in their well-being (Agarwal et al., 2021). Considering that assurance affects the perceived quality of online learning (Uppal et al., 2018), there is an assumption that there is also a connection between assurance and pretensions towards Industry 5.0 in the function of the quality of online higher education. Therefore, a built system of trust in the existing online learning environment should be a good "jumping board" for moving towards Industry 5.0. Therefore, hypothesis six reads:

H6. Assurance impacts students' perception of Industry 5.0 effects on online higher education quality.

The human-centric approach requires mutual empathy and communication, as well as collaborative intelligence, to provide reliable human-computer/machine co-evolution relationships (Lu et al., 2022). Empathy is vital to bringing the service closer to the customer (Nicoletti, 2021) and includes the service provider's caring and individualised attention to its customers (Udo et al., 2011). Students come with different backgrounds, cultures, and issues, and they highly evaluate faculty when they get individual services based on their wants and needs (Sumi & Kabir, 2021). The presence of empathy in the online learning environment leads to satisfaction and motivation (Rasheed et al., 2022). There is an assumption that the presence of empathy on the part of lecturers in the online learning environment affects the perception of applying Industry 5.0 in higher online education. Hence, hypothesis seven is set:

H7. Empathy impacts the students' perception of Industry 5.0 effects on online higher education quality.

The relationship of the constructs is shown through the conceptual model in Figure 1.

3. METHODOLOGY

3.1. Sample

Random sampling was used in this study. The responses were received through an online survey. Since an online-based survey

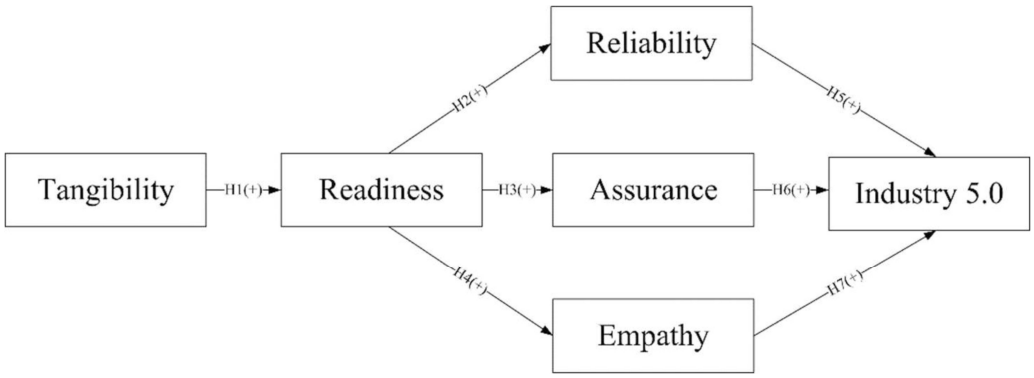

Figure 1. Conceptual Model

allows many respondents to participate in the research, the method is recognised as suitable. In order to create an online questionnaire to evaluate the research questions, a Public Platform, "Google INC: Google Docs," was employed. The data collection process was comprised of two parts. Initially, 100 students were involved in the pilot study to ensure scale validity and reliability. After the pilot survey, a random sampling technique was used, and 532 responses were collected. Students from the management and organization bachelor studies program at the University of Belgrade participated in this research. The majority of respondents (66.85%) have experience in an online or combined education model between 1-2 years, followed by experience between 2-4 years (31.26%). These results indicate that most respondents follow trends and quickly adapt to new education technologies.

3.2. Measurement instrument

In order to operationalise and measure the application of technologies of Industry 5.0 and the dimensions of service quality of online education, the SERVQUAL model (Parasuraman et al., 1988) was used as a research instrument, containing five dimensions with 25 items, including Tangibility, Reliability, Readiness, Assurance and Empathy for online higher education in Industry 5.0. Accordingly, the research instrument was extended to an additional eight variables regarding student perception of Industry 5.0 in online education. Data collected was analysed by using SPSS 17.0 and AMOS 16.0. Table 1 depicts the analysis of the descriptive statistics of the research dimensions.

The results shown in Table 1 present the means and standard deviation of analysed service quality dimensions concerning Industry 5.0. The questionnaire utilised for the data consisted of a 4-point Likert scale ranging from "4 = strongly agree "to "1 = strongly disagree ". The measurement scale is based on previously validated instruments, and the item's statements are slightly modified according to Industry 5.0 paradigm. The score means for the quality of service is 2.77, which shows that students are slightly satisfied with the overall quality of service of their educational institutions. The mean value indicates that the students are most satisfied with the dimension of the Tangibility of online education (3.29). Regarding the application of technologies for current industrial trends, students showed the highest level of satisfaction (3.39). The findings are discussed in the following section.

4. DATA ANALYSIS AND RESULTS

Causal relationships between the quality of services and their direct impact on

Table 1. Descriptive statistics of dimensions

	Mean	Std. deviation	N
Tangibility	3.29	1.19	532
Reliability	2.46	0.57	532
Readiness	2.48	0.55	532
Assurance	2.79	0.59	532
Empathy	2.81	0.79	532
Industry 5.0	3.39	0.37	532

applying Industry 5.0 principles in online higher education were tested using Structural Equation Modeling (SEM). First, the values of the exploratory factor analysis were calculated to see if there is a certain degree of interdependence between the observed variables of the service quality dimensions. The statistically significant value of Bartlett's Test of Sphericity (χ^2=2929.444, d*f*=300, p<0.001) indicates a certain degree of interdependence between the variables. Therefore, it is justified to apply factor analysis. The KMO indicator is 0.881, which, according to the recommendations of Hair et al. (2010), values higher than 0.80 are considered good values. Exploratory factor analysis showed five factors representing quality dimensions whose initial characteristic roots have a value greater than 1. Factor loadings are shown in Table 2. The obtained factor composition explains 46.23% of the common variance.

Following the structure, the factors, i.e. dimensions of quality, are named as follows: Factor 1 – Tangibility in online higher education; Factor 2 – Reliability in online higher education; Factor 3 – Readiness in online higher education; Factor 4 –

Table 2. The Matrix of Factor Analysis

Dimensions of service quality	**1**	**2**	**3**	**4**	**5**
Tangibility in online higher education					
T1	0.657				
T2	0.500				
T3	0.739				
T4	0.596				
T5	0.404				
Reliability of online higher education					
R1		0.509			
R2		0.644			
R3		0.714			
R4		0.738			
R5		0.694			
R6		0.643			
Readiness for online higher education					
RD1			0.574		
RD2			0.689		
RD3			0.740		
RD4			0.654		
Assurance in online higher education					
A1				0.699	
A2				0.650	
A3				0.633	
A4				0.771	
Empathy in online higher education					
E1					0.729
E2					0.412
E3					0.563
E4					0.720
E5					0.560
E6					0.644
% Variance	23.496	7.523	6.139	4.673	4.403
% Cumulative	23.496	31.019	37.158	41.831	46.234

Assurance in online higher education; and Factor 5 - Empathy in online higher education.

When evaluating the quality of a measuring instrument, an important indicator is a reliability (Churchill, 1979). The Cronbach alpha coefficient was used to calculate the internal consistency coefficient. In the literature, all values over 0.70 are considered acceptable (Nunnally, 1978). However, in preliminary research, the lower threshold of acceptance is 0.50 (Churchill, 1979). The obtained coefficients for the quality dimensions are 0.530, 0.738, 0.580, 0.625, and 0.660, respectively. The matrix of correlations between the dimensions of service quality and the overall assessment of the quality service process is shown in Table 3, where a positive correlation with statistical significance can be observed (p<0.01).

The χ^2 value was calculated to evaluate the fit of the model. The normalised value of the χ^2 test indicated χ^2/df=1.714 in the service quality measurement model and the χ^2/df=1.661 in the whole measurement model. According to Marsh and Hocevar (1985), a value lower than five indicates a good model specification achieved in both models. The Index fit indicators of the service quality measurement model and the whole measurement model are presented in Table 4 and indicate how well the defined models reproduce the covariance between the observed variables (Hair et al., 2010). The obtained values of the index fit exceed the minimum acceptable value of 0.90, which indicates a good fit for both models.

Table 5 presents the values of Confirmatory Factor Analysis (CFA) for the assessment of the service quality measurement model and the whole

Table 3. Correlation Between Dimensions of Service Quality and Overall Rating of Service Quality

	Tangibility	Reliability	Readiness	Assurance	Empathy
Tangibility	**1**				
Reliability	0.398	**1**			
Readiness	0.290	0.622	**1**		
Assurance	0.290	0.459	0.483	**1**	
Empathy	0.374	0.516	0.527	0.573	**1**
Overall quality ratings	0.642	0.765	0.747	0.756	0.531

Note: Correlations are significant at the p=0.01 significance level

Table 4. Goodness-of-Fit

Fit indices of the service quality measurement model					
Goodness-of-fit indices	**χ^2 / df**	**RMSEA**	**CFI**	**IFI**	**TLI**
Sample values	1.714	0.037	0.936	0.920	0.936
Recommended value	5	≤0.05	≥0.90	≥0.90	≥0.90
Fit indices of the whole measurement model					
Goodness-of-fit indices	**χ^2 / df**	**RMSEA**	**CFI**	**IFI**	**TLI**
Sample values	1.661	0.035	0.941	0.942	0.932
Recommended value	5	≤0.05	≥0.90	≥0.90	≥0.90

Notes: Root Mean Square Error of Approximation

Table 5. Confirmatory Factor Analysis

Assessment of service quality measurement model parameters and reliability coefficients					Assessment of whole measurement model parameters and reliability coefficients		
Construct	**Items**	**Standardised Item loading**	**t-value**	**Composite reliability (CR)**	**Standardised Item loading**	**t-value**	**Composite reliability (CR)**
Tangibility in online higher education	T1	0.553		**0.462**	0.550		**0.476**
	T2	0.410	6.638		0.400	6.490	
	T3	0.373	6.258		0.396	6.442	
	T4	0.132	2.442		0.165	2.927	
	T5	0.429	6.927		0.434	6.866	
Reliability of online higher education	R1	0.438		**0.730**	0.439		**0.732**
	R2	0.579	8.315		0.577	8.325	
	R3	0.579	8.281		0.582	8.319	
	R4	0.600	8.416		0.604	8.461	
	R5	0.598	8.430		0.599	8.465	
	R6	0.542	8.054		0.551	8.144	
Readiness for online higher education	RD1	0.392		**0.583**	0.390		**0.583**
	RD2	0.579	7.534		0.586	7.459	
	RD3	0.554	7.378		0.549	7.273	
	RD4	0.504	7.121		0.506	7.027	
Assurance in online higher education	A1	0.587		**0.632**	0.592		**0.633**
	A2	0.457	8.076		0.465	8.284	
	A3	0.559	9.272		0.551	9.265	
	A4	0.586	9.719		0.585	9.830	
Empathy in online higher education	E1	0.554		**0.623**	0.608		**0.646**
	E2	0.341	6.233		0.331	6.316	
	E3	0.381	7.175		0.406	7.459	
	E4	0.450	8.585		0.444	8.735	
	E5	0.645	9.278		0.650	9.890	
	E6	0.403	7.556		0.440	7.940	
Industry 5.0 perception	I5_1				0.651		**0.904**
	I5_2				0.825	17,952	
	I5_3				0.702	13,383	
	I5_4				0.818	14,828	
	I5_5				0.671	14,576	
	I5_6				0.753	13,977	
	I5_7				0.708	12,665	
	I5_8				0.740	14,102	

measurement model. In addition, the results of standardised values of factor loadings and t-values were shown, and the composite reliability indices were calculated according to the formulas defined by Fornell and Larcker (1981).

A good fit between the estimated and observed covariance matrix enabled the testing of causal relationships between dimensions of service quality and their direct impact on applying Industry 5.0 principles in online higher education. An evaluation of the fitting parameters of the structural model was performed, and the obtained values of the fitting index are shown in Table 6. The obtained values of the fitting index are within the limits of satisfactory values, which indicate a good fitting of the structural model (Figure 2) and enable testing of structural relationships between latent variables included in the conceptual model.

The research results indicate a significant

direct influence of Tangibility on Readiness (β=0.730, p<.001), which represents a significant direct determinant of Reliability (β=0.899, p<.001), of Assurance (β=0.819, p<.001), and of Empathy (β=0.872, p<.001) in online higher education. These results confirmed hypotheses H1, H2, H3, and H4. Also, the results show a positive direct relationship of Reliability on the students' perception of Industry 5.0 effects on online higher education quality with statistical significance (β=0.366, p<.001), which confirmed hypothesis H5. However, the results indicate a negative relationship between Assurance and the student's perception of Industry 5.0 effects on online higher education quality (β=-0.327, p<.001). Therefore, despite statistical significance, hypothesis H6 cannot be accepted. Also, a negative direct impact can be observed with Empathy on the student's perception of Industry 5.0 effects on online higher education quality (β=-0.053, p<.001). Therefore, hypothesis H7 is also rejected.

5. DISCUSSION

In online higher education, digital tangibles such as IT equipment, learning

Table 6. Structural Model

Fit indices of the structural model					
Goodness-of-fit indices	**χ^2/ df**	**RMSEA**	**CFI**	**IFI**	**TLI**
Sample values	1.688	0.036	0.938	0.939	0.929
Recommended value	≤3.00	≤0.05	≥0.90	≥0.90	≥0.90

Testing of hypotheses			
Hypotheses	**Standardised Item Loading**	**t-value**	**The result of hypothesis**
H1: Tangibility - Readiness	0.730	5.752	Accepted
H2: Readiness - Reliability	0.899	6.431	Accepted
H3: Readiness - Assurance	0.819	7.056	Accepted
H4: Readiness - Empathy	0.872	7.106	Accepted
H5: Reliability – Industry 5.0	0.366	2.560	Accepted
H6: Assurance – Industry 5.0	-0.327	-2.616	Not accepted
H7: Empathy – Industry 5.0	-0.053	-0.405	Not accepted

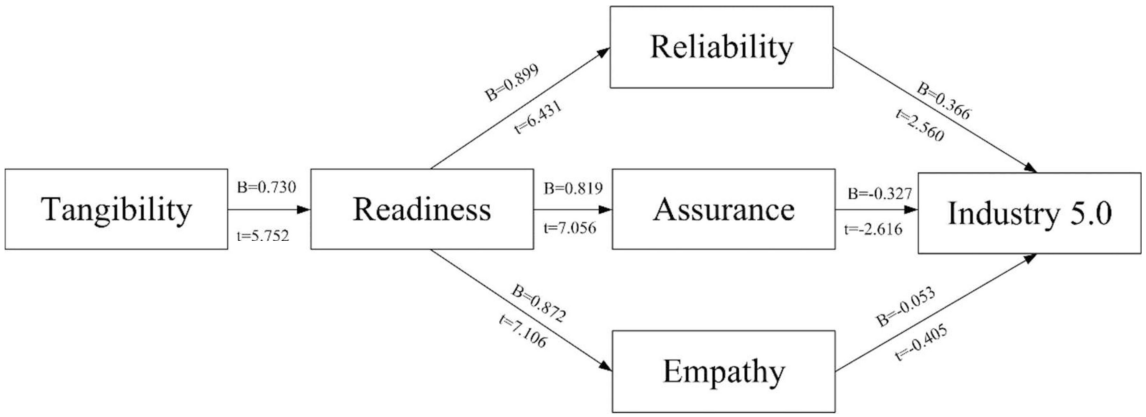

Figure 2. Structural Model

platforms and materials are carriers of possibilities for the application of Industry 4.0. In union with the quality features of Society 5.0. it is possible to create an environment for applying Industry 5.0 in online higher education. Therefore, the paper investigates the mutual relationships of the SERVQUAL model variables, which include both tangible elements and four human-oriented elements. Additionally, it was analysed how these SERVQUAL elements influence the user's perception of the Industry 5.0 application in the online environment. With that aim, seven hypotheses were examined in the paper using the SEM methodology.

As the driver variable, digital tangibles are considered in relation to readiness in online higher education within the first hypothesis. Results indicate tangible elements have a positive impact on readiness for online higher education, conforming H1 hypothesis. Statistically supported, a strong relationship between these variables was established (β=0.730, p<.001), which corresponds to the initial assumptions that the quality of digital tangible is a key element for upgrading Industry 5.0 with elements of Society 5.0. On the other hand, readiness is recognised as a crucial component of Society 5.0 for success in implementing Industry 5.0 (Ferreira & Serpa, 2018). This is also in accordance with the conclusions of other authors who have recognised the significance of the tangibles-readiness relationship (e.g. Catal & Tekinerdogan, 2019; Kuts & Lavrentieva, 2022; Maddikunta et al., 2022).

Further, since readiness is recognised as a factor of users' feelings of reliability in the online environment (Mian et al., 2020; Maddikunta et al., 2022), the second hypothesis is constructed to investigate their relationship. The strong positive impact of the readiness-reliability relationship is determined (β=0.899, p<.001), pointing out the importance of lecturer readiness and commitment to providing high-quality online education service. Hence, hypothesis H2 is accepted. In this regard, the reliability of online education, which is characterised by the commitment, competence and interest of the lecturers, indicates the importance of humans as a building link in ensuring the sustainability of Industry 5.0 (Sung et al., 2011; Catal & Tekinerdogan, 2019).

The following hypothesis, H3, assumes readiness has a positive impact on the assurance, which is confirmed by the obtained results (β=0.819, p<.001). This also could be aligned with some previous observations that lecturers' readiness for curriculum and non-curriculum activities may build trust in student reliability, security and belongingness in online higher education based on the lecturers' competence, experience, and knowledge (Udo et al., 2011; Main et al., 2020; Agarwal et al., 2021). Furthermore, in the context of Industry 5.0, which harmonises the relationship between humans and technology, the results confirm that the more dedicated and competent lecturers are, the higher the perception of assurance among students is.

The relationship between readiness and empathy in online higher education is confirmed by strong statistical significance supporting H4 (β=0.872, p<.001). In the online mode of higher education, lecturers and students are surrounded by technologies and do not have traditional direct contact during classes. Therefore, lecturers are expected to understand and be much more committed to student-specific needs as well as be accessible to achieve a satisfactory level of empathy. Such conclusions align

with Mazur and Walczyna (2022) and Bakir and Dahlan (2022).

After passing through the hypotheses that examine the relationship of digital tangibles to certain SERVQUAL model dimensions, which are considered specific elements of Society 5.0, the impact of these variables on the students' perception of Industry 5.0 effects on online higher education quality is considered.

Firstly, the relationship between reliability and Industry 5.0 in online higher education is observed within H5, which is accepted (β=0.366, p<.001). These findings correlate with Naveed et al. (2021), who recognised the relationship between reliability and students' motivation to use the online education system. Furthermore, it is also concluded that the ability of faculty to perform the promised education service accurately, on time, and dependably and in line with curricula (Milojević & Radosavljevic, 2021; Tumsekcali et al., 2021) results in increased satisfaction and usage of the online higher education system. According to Gregory et al. (2019), lecturers can contribute to reliability in online education through improved communication systems in Industry 5.0.

On the other hand, when testing hypotheses H6 and H7, it is noticed that Assurance-Industry 5.0 perception (H6) and Empahty-Industry 5.0 perception (H7) are not proven relations.

Although it is recognised in the literature that assurance is related to students' willingness to be more successful (Agarwal et al., 2021; Uppal et al., 2018), the assumption that assurance affects students' perception of Industry 5.0 effects on education quality is not confirmed in the researched context. This is because educational technology in Industry 4.0 can be very useful but even more ineffective when it is used without interaction, attention and dedication to each student individually. Even if technologies are advancing rapidly, we are increasingly witnessing the misuse of data and exposure to risks related to AI issues, copyrights and comments that remain on platforms, so a large number of measures are needed to solve that problem, which definitely affects the building of assurance. However, it should be kept in mind that assurance is a specific dimension in relation to the other considered categories in that it is highly abstract. Consequently, assessing its impact in a completely new environment is difficult. Such conclusions are in favor of rejecting this hypothesis 6.

In a technological environment where people work and study online, they are less likely to engage in physical interaction, which contributes to the loss of the element of professor-student empathy and vice versa. Industry 5.0 brings advanced personalized technologies such as adaptive learning systems, AI assistants and algorithms for curriculum adaptation (Maddikunta et al., 2022). These systems can provide student support without interacting with the teacher, which suffers from the concept of empathy, so it is rational that hypothesis 7 is rejected.

In support of this, considering the paradigm of Industry 5.0 is the coming era, the components of Society 5.0, such as assurance and empathy, which development requires time and human commitment, are still challenging to evaluate. A possible reason could be that building an attitude through a sense of belonging, safety, and security cannot be instantly achieved. Therefore, the challenge for lecturers in online higher education is to fully exploit technology in Industry 4.0, emphasising returning the student to the centre of the

educational system as the most important value of Industry 5.0.

6. CONCLUSION

In this paper, SERVQUAL quality variables relationships were tested in the proposed model, and their influence of Industry 5.0 effects on online higher education quality from the student perspective. Higher education quality in the online environment was evaluated by observing the gap between students' expectations and satisfaction regarding each SERVQUAL dimension which results are used as input in the SEM model. Applying SERVQUAL-SEM methodology in online higher education overcomes the previously recognised literature gap.

The contribution is reflected in the timeliness of observing indicators of the quality of higher education in the new industrial environment and in not neglecting student needs for empathy, readiness, reliability, and assurance in such a fast-growing technological environment. The practical contribution is reflected in the definition of the roadmap for quality improvement of higher education institutions to maximise the Industry 5.0 effects on online higher education process quality. Accordingly, it is important to follow the development of technology and explore the ways in which it can be applied in the educational environment. It is also important to ensure that staff have the appropriate skills and knowledge to use technology effectively and to improve the online education process continually. Understanding Industry 5.0 and Society 5.0 accurately is key for developing the corresponding theories, methods, and applications in the educational process. Finally, the results can serve decision-makers in defining future educational strategies at all levels.

The research limitations are that the sample is only from one region and that there is still insufficient time for a more detailed assessment of Industry 5.0's assurance and empathy in higher education. Industry 5.0 is a relatively new phenomenon, so its potential effects on higher education and society are still being learned. In addition, assurance and empathy are very abstract dimensions; hence, evaluating their influence in such a new environment is quite challenging. Therefore, more time is needed to research and analyse the various aspects of Industry 5.0 and its impacts on higher education to make more reliable assessments of its security and empathy. The study is also limited to students enrolled in the Management and Organization bachelor's program at the University of Belgrade. Therefore, the findings may not be relevant to those studying in STEM, humanities, or other fields. Future research should consider including students from various universities and academic programs. Additionally, comparisons across different countries could be conducted to explore variations in culture and institutional frameworks.

Further research would include upgrading the conceptual model with a detailed focus on technological, social, and ethical issues, privacy, and data protection, as well as the potential increase in inequality in accessing or adapting to new technologies. Therefore, it is important to consider these challenges when considering the future development of Industry 5.0 in higher education. Also, examining the impact of Education 5.0 outcomes on Industry 5.0 needs would be an additional challenge for researchers.

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ВИСОКО ОБРАЗОВАЊЕ У СВЕТЛУ ИНДУСТРИЈЕ 5.0: SERVQUAL-SEM ДИМЕНЗИЈЕ КВАЛИТЕТА

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Извод

Индустријска револуција покреће развој друштва, а њена трансформација одражава предстојећу индустријску револуцију. То је довело до Индустрије 5.0 и Друштва 5.0 у многим областима, чак и у образовању. Стога, универзитети треба да постигну висок ниво квалитета услуга како би се ускладили са новим индустријским трендовима где се од људи очекује да буду иновативни и сараднички настројени у заједничком радном окружењу са новим дигиталним технологијама. Стога, циљ овог рада је да истражи везу између *SERVQUAL* варијабли квалитета онлајн високог образовања (опипљивост, поузданост, спремност, сигурност и емпатија) и њихов утицај на перцепцију студената о ефектима Индустрије 5.0 на квалитет високог образовања. Да би се постигао овај циљ, анкета је спроведена међу 532 универзитетска студента. Структурно моделовање једначина (енг. *Structural Equation Modeling*-SEM) показује да су сви анализирани односи између *SERVQUAL* варијабли потврђени и указују на позитиван утицај. Штавише, разматран је и утицај поменутих варијабли квалитета на перцепцију студената о ефектима Индустрије 5.0 на квалитет високог образовања. Узимајући у обзир те односе, поузданост је једина значајна варијабла која утиче на перцепцију студената о ефектима Индустрије 5.0 на квалитет високог образовања. Ови закључци би могли бити коришћени за развој оквира за побољшање квалитета онлајн високог образовања у Индустрији 5.0, што би довело до основе за развој новог Друштва 5.0.

Кључне речи: Индустрија 5.0, Друштво 5.0, високо образовање, модел квалитета *SERVQUAL-SEM*

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