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Mixed-mode Emergency Learning: Engineering Students Experience*

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Due to the global COVID-19 pandemic, educational institutions were compelled to transition from traditional learning to emergency remote e-learning rapidly. In light of this, the present study aims to investigate the effect of a broader range of student characteristics on attitudes towards e-learning during the pandemic in a mixed-mode learning environment. The investigated students' characteristics are gender, previous experience in e-learning, perceived level of IT skills, high school background, study program indicative of the extent of technology use, teaching method employed during the pandemic, time devoted to e-learning, the device employed for e-learning, and residence status. The newly developed Students' Attitudes Towards E-learning Scale (SAES) was administered to a sample of 1058 first-year engineering students at the University of Novi Sad. The results of factor analysis revealed three factors of the SAES: positive attitudes, negative attitudes, and institutional support for emergency e-learning. Results showed that students from different study programs showed significant differences in their perception of online learning, indicating the role of the course curriculum. Additionally, students from the gymnasium (grammar school) who attended online classes during the pandemic and had prior experience in e-learning showed more positive attitudes towards e-learning, while students who engaged in the combined teaching method in high school and spent more hours in e-learning showed more negative attitudes towards e-learning. Gender does not affect attitudes towards e-learning. Emphasising the importance of examining diverse student characteristics, this study highlights institutional support for e-learning for commuter students and those who spend more time on e-learning.

Keywords: emergency e-learning; mixed-mode learning; COVID-19 pandemic; engineering students

1. Introduction

The COVID-19 pandemic significantly impacted many aspects of life, including the educational system. Serbian authorities declared a state of emergency on March 16th, 2020, leading to the nationwide closure of all educational institutions. In response, the Ministry of Education, Science, and Technological Development instructed universities to prepare for distance learning models, reschedule ongoing exams, and assist students online to prevent the spread of the virus. Traditional classrooms were replaced with virtual environments using information and communication technologies to maintain the teaching process. Teachers adapted their educational plans for virtual classrooms, and high school teaching was organised according to different models depending on technical possibilities. Due to unfavourable epidemiological situations, face-to-face teaching was impossible in November and December 2020, and teachers conducted online teaching via video-conferencing platforms such as Zoom, Google Meet, and Microsoft Teams. In some schools, learning materials and assignments were uploaded on platforms like Google Classroom and Moodle or sent to students via email and chat services like Viber. Overall, in the academic year 2020/21, high schools conducted combined teaching, and most faculties held lectures through the MS Teams platform.

E-learning, or distance or online learning, involves acquiring knowledge through internet-based applications. This method has proven effective, especially in technologically advanced countries [1, 2]. Various online learning models exist, such as open online courses, recorded lectures, live online interactions, tutorials, brief communications, and conferences [3]. E-learning offers different information formats like text, audio, images, videos, simulations, etc. This flexibility allows students to engage with coursework at their own pace and location [4]. Moreover, it enables educators to deliver instructional materials conveniently at their preferred time and place. In many ways, e-learning surpasses traditional education because of its accessibility and ease of use [5]. The availability of innovative tools enhances the appeal of lectures [6], and it also proves cost-effective by eliminating

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the need for student and faculty travel. Several studies consistently report positive attitudes toward e-learning among students and educators [7–9]. However, there are some disadvantages of e-learning. First, the lack of face-to-face communication between students and teachers, an opportunity for real-time group discussion, and communal learning might make e-learning less effective [10–12]. Second, e-learning increases the possibility of cheating and plagiarism [13]. Third, some students' lack of self-motivation and independence can reduce their success rates compared to their colleagues [14]. In addition, the disadvantages are the lack of personal technical equipment regarding financial support, internet connection problems, and insufficient information and communication technology knowledge [15–17].

Numerous studies have been conducted to investigate students' perceptions of e-learning during the pandemic [5, 16, 18–21]. The main advantages of e-learning during the pandemic align with the general advantages of e-learning, such as the possibility to stay at home, continuous access to online materials, the opportunity to learn at your own pace, and comfortable surroundings [10, 16, 20]. The main problem for students, especially first-year students, was a lack of socialising with other students and professors. The lockdown has influenced academic studying and the possibility of experiencing university campus life [22]. During the online classes, students felt tired and missed the traditional classrooms [19]. Significant disadvantages were the lack of concentration and motivation [10, 12] and technical problems with IT equipment [16]. Khan et al. [19] found that most students used mobile phones for e-learning. Therefore, many said the temptation to watch other sites, check messages, or pick up calls deviates interest from online classes.

Digital technology is necessary for e-learning and requires using the Internet and software to create educational materials, teach students, and administer courses [20]. The effectiveness of e-learning is manifested in digitally developed countries [23]. Compared to digitally developed countries, developing countries face many challenges in implementing e-learning, including poor internet connection quality, mobile signal coverage, etc. [15]. Seada and Mostafa [24] showed that most students in digitally undeveloped countries faced difficulties accessing the hardware and software needed for e-learning and often errors in an internet network system. In addition to these technical problems, the issue with organising e-learning in digitally undeveloped or developing countries is low digital literacy [25]. Digital literacy is strongly connected to effective e-learning and is highly relevant to contemporary educators [26]. In Serbia, digital literacy decreased [25], which could affect the involvement of new learning technologies and methods based on information communication technologies. Besides technical conditions, individual factors could also affect attitudes towards e-learning.

Our study was conducted with undergraduates in their first year of academic studies at the University of Novi Sad. The investigation of the first-year students was an exceptional opportunity because they attended high school and faculty teaching courses in online combined and mixed-mode environments [27] due to the pandemic. From March 2020 until the end of the academic year 2019/20, classes at the faculty took place through several different platforms (Zoom, Moodle, Sova, Skype, etc.). From the start of the academic year 2020/21 till the end of the academic year 2021/22, lecture classes have been conducted exclusively using the Microsoft Teams online platform. However, experimental exercises were performed face-to-face in the laboratories with the adjustment of the group size to the directives for monitoring COVID-19. For this reason, students not accommodated in Novi Sad need to find accommodation (dorms or rented apartments) in the city or travel daily. The latest group of students completed their entrance exam and all subsequent academic year exams within the faculty's premises, as required by the higher education law of the Republic of Serbia [28].

The study aims to explore the newly developed Students' Attitudes Towards E-learning Scale (SAES) factor structure and examine the effect of a broader set of student characteristics on attitudes towards e-learning during the COVID-19 pandemic in a mixed-mode learning environment. In line with previous studies [19, 29] we expected to extract factors related to positive and negative attitudes towards e-learning.

Through extensive research on distance learning and emergency e-learning [30], it has become clear that the pros and cons of this educational approach have been thoroughly examined and remain sufficiently consistent across published studies. Nonetheless, it is vital to acknowledge this topic's importance and call for further research [31, 32] as education is a fundamental pillar of all societies. Moreover, with a rise in crises such as epidemics, natural disasters, and man-made disasters (i.e., war and nuclear catastrophes), exploring the implications of these learning models during emergencies is crucial, even if it poses challenges in drawing fresh conclusions and insights [33].

This study is an insightful addition to existing research, confirming that educational institutions worldwide responded swiftly and effectively during the crisis. Notably, the Republic of Serbia was the

third country in Europe to start a mass immunisation campaign for giving the vaccine, which enabled secondary schools and colleges to implement a combined, blended, or mixed teaching model. Through this study, we aim to enhance our understanding of e-learning from this perspective, trying to fill a gap in research. We also drew on the valuable insights of engineering students, who provided a helpful reference for concluding implementing this learning model, considering their technology knowledge and skills.

This paper also addresses socio-demographic characteristics of high school students that have yet to be fully explored in prior research. It focuses on the approach to classes during the final year of school amid a crisis and relevant study programs that include theoretical, computational, and experimental classes. Additionally, the paper examines student accommodations during the pandemic, a crucial factor to consider when assessing different aspects of e-learning.

2. Materials and Methods

2.1 Sample and Procedure

The sample included 1058 students in the first year of the 18 programs at the Faculty of Technical Science, University of Novi Sad, which were grouped into six groups of programs (Table 1). The study was approved in written form by the Ethical Commission of the Faculty of Technical Sciences, University of Novi Sad, Serbia (No.01-2255/1). The research was conducted in two phases, based on the study program and course curriculum, as the sample comprised students who participated in a mixed-mode learning environment. The first

Table 1. Demographic characteristics of the sample (N = 1058)

Variable	Categories	*n*	%
Gender	Female	408	38.6
	Male	650	61.4
High school background	Technical and technological	446	42.2
	Social and humanistic	100	9.5
	Science and Mathematics	251	23.7
	Gymnasium	261	24.7
Previous experience in e-learning	Yes	284	26.8
	No	774	73.2
Teaching method during the COVID-19 pandemic	Combined	700	66.2
	Only via platforms	311	29.4
	Only face-to-face	47	4.4
Used device for e-learning	Laptop	765	72.3
	PC	239	22.6
	Mobile	54	5.1
Time spent on e-learning	1–3	207	19.6
	3–5	358	33.8
	5–7	389	36.8
	More than 7	104	9.8
Perceived IT skills	Low	153	14.5
	Medium	677	64.0
	High	228	21.6
Study program	Electrical and Energy Engineering	218	20.6
	Computing and Automation	249	23.5
	Civil engineering	258	24.4
	Environmental engineering	70	6.6
	Mechanical engineering	113	10.7
	Applied computer science	150	14.2
Residence status	I currently live in Novi Sad in a dorm	99	9.4
	I currently live in Novi Sad in privately provided accommodation	583	55.1
	I travel to Novi Sad when I have university commitments	173	16.4
	I was born and currently live in Novi Sad	203	19.2

group of participants took part in a paper survey from February 21 to March 4, 2022, at the end of the first semester, while the second phase of the survey was held from June 13 to June 24, 2022, after the end of the second semester. The students were verbally informed about the voluntary research study and confirmed their participation in writing within the questionnaire.

2.2 Measure

A recent research study aimed to develop a comprehensive measurement tool for assessing student attitudes towards e-learning. The resulting Students' Attitudes Towards E-learning Scale (SAES) consisted of 54 items, each rated on a 5-point Likert scale ranging from strongly disagree to strongly agree. The survey covered a range of e-learning topics, including the benefits of distance learning and the challenges posed by COVID-19, with 19 items devoted to these subjects. Additionally, the questionnaire included eight items related to barriers in using the internet, platforms, and devices for e-learning, ten items focused on communication and accessing supporting materials through platforms, and 17 items for comparing online and traditional teaching methods. The SAES scale was designed to assess student attitudes towards e-learning across these diverse areas comprehensively. The survey was created using the findings of Bączek et al. [16] and tailored for engineering students. Some questions were obtained from Panorama Education's website (Panorama Education, n.d.), while others were created by authors based on student interviews regarding complexity and subject specificity.

2.3 Data Analysis

Exploratory factor analysis (EFA) was utilised to investigate factor structure and item selection. The process is comprised of two steps. Firstly, the items were selected based on their correlations with unrotated principal components greater than 0.30. The Principal Axis Factoring (PAF) method was used for the remaining items. Three factors were selected based on the Scree diagram, and varimax rotation was used. The selection of items was based on their correlations with factors, with preference given to those having a high correlation with factors and non-significant cross-loadings. Multivariate analysis of variance (MANOVA) was used to investigate the effects of various students' characteristics on their attitudes towards e-learning during the COVID-19 pandemic. Scheffe's post hoc test was used for significant effects. If the assumption of equality of covariance was not violated, the *F*-test for the corrected model was used. Similarly, if Levene's test of equality of variance was significant, the corrected *F*-test was used. All analyses were run in IBM SPSS v.26 [34].

3. Results

3.1 Factor Structure of the Students' Attitudes Towards E-learning Scale (SAES)

The initial Principal Component Analysis (PCA) performed on 54 items revealed that many exhibited low correlations with the principal components. Some items showed low correlation with the first component but stronger correlations with the second component, suggesting a multidimensional structure for the scale. We excluded eight items with low correlation with the first and second components to maintain this multidimensionality.

In the subsequent step, we applied a three-factor solution based on the Scree diagram (Appendix A). During this process, we eliminated seven items with notable cross-loadings. This refining process resulted in a final set of 39 items, upon which a Principal Axis Factoring (PAF) analysis with varimax rotation was again conducted.

This study identified three factors that explained different aspects of e-learning. The first factor, named positive attitude towards e-learning, consisted of 18 items and explained 19.38% of the common variance. This factor highlighted the advantages of e-learning, such as the opportunity for students to increase their knowledge, information, and skills during their education. The second factor, institutional support for e-learning, consisted of 11 items and explained 10.45% of the common variance. This factor refers to the technical aspects of e-learning, including interaction, communication, presentation, and availability of materials. The third factor, negative attitudes towards e-learning, consisted of 10 items and explained 9.57% of the common variance. This factor identified the disadvantages of e-learning, such as reduced possibility of acquiring practical skills and solving problems, limited interaction and communication, and the inability to express creativity and ideas using e-learning entirely.

3.2 Descriptives and Alpha Reliabilities of the Students' Attitudes Towards E-learning Scale (SAES)

The skewness and kurtosis for all scales do not exceed +/–2 (Table 3), indicating that normal distribution is not violated [35]. Alpha reliabilities are acceptable for all scales (Table 3).

3.3 Effects of Students' Characteristics on Attitudes towards E-Learning

Gender. There is no significant gender differences in

Table 2. Pattern matrix of the final Students' Attitudes Towards E-learning Scale (SAES)

Items	Factors' loadings		
	1	**2**	**3**
E-learning enables students to enhance their information, knowledge and skills during their education.	**0.77**	0.14	–0.21
In my view, e-learning facilitates more efficient knowledge acquisition.	**0.74**	0.08	–0.27
E-learning enhances my understanding of the subject.	**0.74**	0.12	0.09
E-learning makes the learning process interesting.	**0.73**	0.13	–0.28
I wish to acquire knowledge and skills through e-learning.	**0.72**	0.11	–0.21
E-learning motivates me to participate in the learning process actively.	**0.71**	0.14	–0.31
Adopting e-learning as a learning style will help students balance college and private commitments.	**0.69**	0.13	–0.08
E-learning enhances the flexibility of teaching and learning.	**0.69**	0.06	–0.04
E-learning enables me to fulfil my student obligations on time.	**0.68**	0.18	–0.03
E-learning reduces the amount of stress.	**0.67**	0.10	–0.16
Adopting e-learning as a learning style in college will contribute to students' effective problem-solving.	**0.63**	0.26	–0.26
E-learning through appropriate platforms improves communication with colleagues	**0.57**	0.08	–0.16
E-learning assists me in catching up on missed lectures.	**0.53**	0.19	0.03
E-learning saves the time and effort for both professors and students.	**0.49**	0.19	–0.05
I would like it to be possible to choose online study programs at the university.	**0.45**	0.04	–0.06
I preferred blended learning.	**0.40**	0.10	0.09
I am concerned that attending "face-to-face" classes might expose me to the COVID-19 virus.	**0.40**	0.04	–0.18
I am concerned that attending classes in a laboratory/classroom might put my elderly or immunocompromised family members at risk of contracting the COVID-19 virus.	**0.35**	0.06	–0.12
Professors are willing to communicate with students through e-learning platforms.	0.08	**0.71**	0.19
Students can communicate with teachers through online communication platforms	0.10	**0.68**	0.21
Professors utilise all available options for electronic presentations of materials during their lectures.	0.10	**0.61**	0.12
E-learning platforms allow for open and free communication with teachers.	0.19	**0.60**	0.21
In addition to presentations, faculty professors also incorporate other technical tools for e-learning, such as graphic boards and multimedia materials.	0.01	**0.59**	0.14
Professors instruct students on using online tools and other electronic resources to complete assignments.	0.17	**0.57**	0.01
Teachers upload essential study materials, such as assignments, tests, and exam results, online	0.06	**0.57**	0.18
The faculty I attend is interested in helping students not technically equipped for e-learning.	0.06	**0.49**	–0.02
The faculty I attend has adequate technical support for the smooth running of e-learning.	0.13	**0.46**	0.01
Professors encourage us to use electronic books, textbooks, and other online educational materials.	0.16	**0.45**	–0.09
The faculty successfully organised classes during the COVID-19 pandemic.	0.26	**0.40**	0.02
I find it challenging to concentrate while attending lectures via e-learning.	–0.19	0.02	**0.68**
I prefer traditional lectures over online learning.	–0.39	0.08	**0.61**
I miss face-to-face teaching in classrooms.	–0.38	0.10	**0.60**
E-learning reduces the possibility of acquiring practical skills and solving problems.	–0.13	0.01	**0.60**
I feel that e-learning restricts my ability to fully express my creativity and ideas.	–0.12	–0.07	**0.58**
Practical work in the laboratory helps me to acquire theoretical knowledge more easily.	–0.07	0.29	**0.56**
Teamwork in the laboratory helps me acquire knowledge and develop my skills.	–0.02	0.27	**0.55**
I prefer reading from printed sources over sources from websites or e-literature	–0.01	0.04	**0.48**
E-learning has limited effectiveness in improving teaching and learning.	–0.09	0.15	**0.48**
E-learning significantly reduces interaction and communication between professors and students.	–0.15	–0.01	**0.46**

Note: Loadings >0.30 were bolded.

Table 3. Descriptive statistics and alpha reliability of the Students' Attitudes Towards the E-learning Scale (SAES) scales

SPES scales	*M*	*SD*	*Sk*	*Ku*	α
Positive attitudes towards e-learning	2.77	0.87	0.42	–0.35	0.93
Negative attitudes towards e-learning	3.88	0.77	–0.61	–0.10	0.84
Institutional support towards e-learning	3.75	0.69	–0.39	–0.35	0.84

Table 4. Descriptive statistics for positive attitudes towards e-learning scale for groups of high school background

High school background (*n*)	*M*	*SE*
Technical and technological (446)	2.57	0.04
Social and humanistic (100)	2.64	0.09
Science and Mathematics (251)	2.71	0.06
Gymnasium (261)	2.79	0.05

attitudes toward e-learning (Wilks' Lambda = 0.99, $F(3,1054) = 2.43$, $p = 0.06$, $\eta_{p^2} = 0.01$).

High school background. Significant differences were found between high school background groups (Wilks' Lambda = 0.98, $F(9,2560.44) = 2.92$, $p = 0.002$, $\eta_{p^2} = 0.01$). Tests of between-subjects effect showed that the differences were found only in positive aspects of e-learning ($F(3,2.984) = 3.97$, $p = 0.01$, $\eta_{p^2} = 0.01$). Gymnasium students showed more positive attitudes than those from technical and technological high schools ($p = 0.01$) (Table 4.). No significant differences were found between other groups ($p > 0.05$).

Previous experience in e-learning. There was a significant difference between the students with experience in e-learning and those who did not have experience in different aspects of e-learning (Wilks' Lambda = 0.99, $F(3,1054) = 2.43$, $p = 0.01$, $\eta_{p^2} = 0.01$). Tests of between-subjects effect showed that the differences were found only in positive attitudes towards e-learning ($F(1,6.78) = 9$, $p = 0.003$, $\eta_{p^2} = 0.01$), with those who had previous experience showing higher scores ($M = 2.79$, $SE = 0.05$) compared to those who did not ($M = 2.61$, $SE = 0.03$).

Teaching method in high school during the COVID-19 pandemic. There were significant differences between groups with different teaching methods during the pandemic (Wilks' Lambda = 0.98, $F(6,2106) = 3.63$, $p = 0.001$, $\eta_{p^2} = 0.01$). Between-subjects tests indicated significant differences in both the positive ($F(2,6.09) = 8.14$, $p < 0.001$, $\eta_{p^2} = 0.02$) and negative ($F(2,2.93) = 5.03$, $p = 0.007$, $\eta_{p^2} = 0.01$) attitudes towards e-learning. According to Scheffe's post hoc tests, students who used e-learning platforms had more positive attitudes than those who attended combined teaching classes ($p < 0.001$) (Table 5). Also, students in combined teaching classes showed more negative attitudes compared to those attending online classes only ($p = 0.02$). The rest of the comparisons were not significant ($p > 0.05$).

Device used for e-learning. There were no significant differences in attitudes towards e-learning between students who use different devices for e-learning (Wilks' Lambda = 0.99, $F(6,2106) = 0.66$, $p = 0.68$, $\eta_{p^2} = 0.002$).

Time spent on e-learning. There were significant differences between groups of students who spent different amounts of time on e-learning (Wilks' Lambda = 0.96, $F(9,2560.44) = 4.34$, $p < 0.001$, $\eta_{p^2} = 0.01$). Tests of the between-subjects effect showed that differences exist in the negative attitudes towards e-learning ($F(3,1.888) = 3.23$, $p = 0.02$, $\eta_{p^2} = 0.01$) and institutional support for e-learning ($F(3,4.639) = 9.88$, $p < 0.001$, $\eta_{p^2} = 0.03$). The results of Scheffe' s post hoc tests showed that students who spent 5–7 hours in e-learning showed more negative attitudes than students who spent 3–5 hours in e-learning ($p = 0.047$). Also, students who spent 3–5 hours ($p = 0.002$) and 5–7 hours ($p < 0.001$) in e-learning showed more positive attitudes towards institutional support for e-learning than the students who spent 1–3 hours (Table 6). Additionally, students who spent 5–7 hours in e-learning showed more positive attitudes towards institutional support for e-learning than those who spent more than 7 hours ($p = 0.03$).

Self-reported IT skills. There are no significant correlations between the perceived IT skills level and attitudes towards e-learning (Table 7).

Study program. There are significant differences in the attitudes towards e-learning among students of various study programs (Wilks' Lambda = 0.94, $F(15, 2898.989) = 4.38$, $p < 0.001$, $\eta_{p^2} = 0.02$). Tests of the between-subjects effect showed that these differences were significant in terms of both positive ($F(5, 3.450) = 4.63$, $p < 0.001$, $\eta_{p^2} = 0.02$) and negative attitudes towards e-learning ($F(5, 3.754) = 6.55$, $p < 0.001$, $\eta_{p^2} = 0.03$). According to the results of Scheffe's post hoc tests, it was found that students who study mechanical engineering have a less favourable attitude towards e-learning compared to students who study electrical and energy engineering ($p = 0.001$). Furthermore, students who

Table 5. Descriptive statistics comparing positive and negative attitudes towards e-learning

Scale	Teaching method (*n*)	*M*	*SE*
Positive attitudes towards e-learning	Combined (700)	2.59	0.03
	Only via platforms (311)	2.83	0.05
	Only face-to-face (47)	2.63	0.13
Negative attitudes towards e-learning	Combined (700)	3.92	0.03
	Only via platforms (311)	3.77	0.04
	Only face-to-face (47)	4.03	0.11

Table 6. Descriptive statistics for negative attitudes and institutional support for e-learning for groups "time spent on e-learning"

Scale	Time spent on e-learning (*n*)	*M*	*SE*
Negative attitudes towards e-learning	1–3 hours (207)	3.82	0.05
	3–5 hours (358)	3.82	0.04
	5–7 hours (389)	3.98	0.04
	More than 7 hours (104)	3.89	0.08
Institutional support for e-learning	1–3 hours (207)	3.56	0.05
	3–5 hours (358)	3.79	0.04
	5–7 hours (389)	3.85	0.04
	More than 7 hours (104)	3.63	0.07

Table 7. Correlation between perceived IT skills and attitudes toward e-learning

Scale		Perceived IT skills
Positive attitudes toward e-learning	*r*	–0.03
	p	0.24
Institutional support for e-learning	*r*	–0.03
	p	0.18
Negative attitudes toward e-learning	*r*	–0.04
	p	0.08

study computing and automation ($p = 0.014$), civil engineering ($p = 0.033$), and applied computer science ($p = 0.012$) had a more positive view towards e-learning. On the other hand, students of computing and automation ($p = 0.012$), civil engineering ($p = 0.050$), mechanical engineering ($p = 0.001$), and applied computer science ($p = 0.001$) had a more pessimistic view than electrical and energy engineering students (Table 8).

Student residences. Significant differences existed between groups of students of different accommodations (Wilks' Lambda = 0.98, $F(9,2560.442) = 2.75$, $p = 0.003$, $\eta_{p^2} = 0.01$). Tests of between-subjects effect showed that differences exist in the positive attitudes towards e-learning ($F(3,3.056) = 4.06$, $p = 0.007$, $\eta_{p^2} = 0.01$) and institutional support for e-learning ($F(3,2.103) = 4.41$, $p = 0.004$, $\eta_{p^2} = 0.01$). Based on Scheffe's post hoc tests, it was shown that students who travel to Novi Sad hold more positive views towards e-learning ($p = 0.029$) and receive greater institutional support for e-

Table 8. Descriptive statistics for positive and negative attitudes towards e-learning among students from different study programs

Scale	Study program (*n*)	*M*	*SE*
Positive attitudes towards e-learning	Electrical and Energy Engineering (218)	2.78	0.06
	Computing and Automation (249)	2.69	0.06
	Civil engineering (258)	2.66	0.05
	Environmental engineering (70)	2.61	0.10
	Mechanical engineering (113)	2.32	0.08
	Applied computer science (150)	2.73	0.07
Negative attitudes towards e-learning	Electrical and Energy Engineering (218)	3.65	0.05
	Computing and Automation (249)	3.92	0.05
	Civil engineering (258)	3.89	0.05
	Environmental engineering (70)	3.84	0.09
	Mechanical engineering (113)	4.07	0.07
	Applied computer science (150)	4.03	0.06

Table 9. Descriptive statistics for positive attitudes towards e-learning and institutional support for e-learning for groups based on residence status

Scale	Student residences (*n*)	*M*	*SE*
Positive attitudes towards e-learning	I currently live in Novi Sad in a dorm (99)	2.81	0.09
	I currently live in Novi Sad in privately provided accommodation (583)	2.59	0.04
	I travel to Novi Sad when I have university commitments (173)	2.82	0.07
	I was born and currently live in Novi Sad (203)	2.67	0.06
Institutional support for e-learning	I currently live in Novi Sad in a dorm (99)	3.77	0.07
	I currently live in Novi Sad in privately provided accommodation (583)	3.73	0.03
	I travel to Novi Sad when I have university commitments (173)	3.91	0.05
	I was born and currently live in Novi Sad (99)	3.67	0.05

Table 10. Summary results for effects of students' characteristics on attitudes towards e-learning

Variable	Categories	*positive attitude towards e-learning*	*positive attitude towards institutional support*	*negative attitude towards e-learning*
Gender	Female	no differences in any of the factors		
	Male			
High school background	Technical and technological	Gymnasium > Technical and technological	no difference	no difference
	Social and humanistic			
	Science and Mathematics			
	Gymnasium			
Previous experience in e-learning	Yes	Yes > No	no difference	no difference
	No			
Teaching method during the COVID-19 pandemic	Combined	Only via platforms > Combined	no difference	Combined > Only via platforms
	Only via platforms			
	Only face-to-face			
Used device for e-learning	Laptop	no differences in any of the factors		
	PC			
	Mobile			
Time spent on e-learning	1–33	no difference	3-5, 5-7 > 1-3 5-7 > 7	5-7 > 3-5
	3–5			
	5–7			
	More than 7			
Perceived IT skills	Low	no correlations with any of the factors		
	Medium			
	High			
Study program	Electrical and Energy Engineering	Electrical and energy engineering, Computing and automation, Civil engineering, Applied computer science > Mechanical engineering	no difference	Computing and automation, Civil engineering, Mechanical engineering, Applied computer science > Electrical and energy engineering
	Computing and Automation			
	Civil engineering			
	Environmental engineering			
	Mechanical engineering			
	Applied computer science			
Residence status	I currently live in Novi Sad in a dorm	Travel to Novi Sad > Privately provided accommodation	Travel to Novi Sad > Privately provided accommodation, Born and currently live in Novi Sad	no difference
	I currently live in Novi Sad in privately provided accommodation			
	I travel to Novi Sad when I have university commitments			
	I was born and currently live in Novi Sad			

Note: the sign ">" denotes the relation between the values of the means.

learning ($p = 0.020$) compared to their peers residing in privately-provided accommodations within the city (Table 9). In addition, students who travel to Novi Sad have more positive attitudes toward institutional support of e-learning than those born and currently living in Novi Sad ($p = 0.009$).

To gain a better insight into how students' characteristics affect their attitudes towards e-learning, the findings are summarised in Table 10.

4. Discussion

Our research has identified three key factors related to engineering students' attitudes towards e-learning: positive attitudes, negative attitudes, and attitudes regarding institutional support for e-learning.

Positive attitudes characterised by increased access to information, knowledge, skills, and flexibility in terms of time and location, have been consistently recognised in previous studies [10, 13, 20, 36, 37].

Negative attitudes, on the other hand, involve concerns such as the loss of concentration, the absence of face-to-face interactions, the departure from traditional classroom settings, limitations on expressing creativity and ideas, and the extended periods spent in front of technology to compensate for the lack of social interaction. These aspects have

also been consistently noted in prior research [10, 12, 38, 39].

Furthermore, Ebaid [40] and Adnan & Anwar [18] state that technical problems and computer dependence are subsequent disadvantages of e-learning. These aspects of e-learning are captured within the extracted factor of institutional support for e-learning. Extraction of this factor indicated that communication between professors and students through e-learning platforms, access to multimedia, and additional learning materials are a significant segment of e-learning. In this respect, Khan et al. [19] also found that access to digital material is a prerequisite for successful e-learning.

Regarding the effects of a broader set of engineering students' characteristics on attitudes towards e-learning, our research offered new variables that could contribute to the better incorporation of e-learning in educational reorganisation in times of crisis.

Gender. At first, we found no differences between men and women in attitudes towards e-learning. This may support Cadrado-García et al. [41] and Al-Juda [42] studies that show that differences in evaluation and use of e-learning depending on gender are rare. However, many authors [43–46] state that female students give a higher average rating to e-learning than male students. In reviewing the literature, we found almost no studies that found gender similarity in attitudes regarding most or all aspects of e-learning. The homogeneous sample i.e. could explain the no significant gender differences in this study; participants are student engineers with previous experience in digital technologies.

High school background. On the other hand, our assumptions were confirmed concerning the impact of previous education on how students perceived e-learning, knowing that students from different high schools have particular skills and qualifications. The results showed that students from the gymnasium have more positive attitudes towards e-learning than students from technical and technological schools. The positive attitude related to e-learning of students who completed gymnasium compared to students from professional schools is probably a consequence of the course's curriculum in the higher grade or teaching methodologies. Nevertheless, in professional schools in the third and fourth grades, students mostly have professional subjects based on practical work, which is impossible to translate fully to the online setting. Moustakas and Robrade's [47] research indicates that University Sport and Physical Education students also face these difficulties in online learning.

Teaching method during the COVID-19 pandemic. Students' attitudes towards distance learning also differ regarding the teaching style used in high school during the pandemic. In any case, these attitudes contrast those of students who engaged in platform-based classes and those who experienced combined teaching methods. While the former emphasises the positive effects, the latter highlights the adverse effects of distance learning, and these opinions are significantly different. According to the students, combined teaching in high schools was implemented so that one group of students attends classes at school for the whole week while the other group is at home, and then the groups change weekly. In most cases, the teaching was not organised in such a way for various reasons (the most often mentioned being technical). In some schools, teachers held parallel classes in the classroom and online courses (for another group of students who followed the classes from home), working with both groups simultaneously. However, the teachers used to upload lessons, presentations, learning materials, and tasks on some learning platforms or refer them to TV lessons. Students with such organised classes point out the disadvantages of emergency e-learning, which are not negligible because these students can compare face-to-face and distance learning from the immediate point of view. Additionally, Grieves et al. [48] point out that engineering students who have experienced online lectures during the pandemic crisis also prefer in-person or hybrid mode learning.

Device used for e-learning. Results have shown no significant differences regarding devices used for distance learning, which agrees with Frohn's [49] study.

Previous experience in e-learning. Contrarily, experienced students who have interacted with diverse learning platforms show an apparent inclination towards the advantages of distance learning. They have garnered insights from pre-pandemic engagements in courses and training, actively refining skills across various online platforms. Alameri et al. [50] also emphasise the students' positive attitude towards Microsoft Teams, Zoom, and Moodle, which allow students many benefits, increasing their ICT skills and improving learning by improving contact between teachers and students [51]. Notably, 73.2% of students had not encountered distance learning before, aligning with findings from Bączek et al. [16].

Study programs. Upon analysing students' viewpoints across various study programs and courses at the Faculty of Technical Sciences, significant disparities become evident between mechanical engineering students and those enrolled in the other five study programs. These disparities primarily pertain to their perspectives on the advan-

tages associated with distance learning. These discrepancies could be attributed to the distinct curriculum of the mechanical engineering study program, which diverges from that of the other programs. Eight of the twelve subjects in the first year are experimental courses with laboratory or computer exercises. Hong et al. [52] emphasised that experimental courses incorporate a hands-on approach to learning, where students can expand their knowledge and perspective by engaging in practical activities. Accordingly, classes were conducted applying the mixed model, meaning theoretical courses were conducted online, and experimental exercises were conducted face-to-face. The analysis demonstrates that students of mechanical engineering and those who had combined teaching in high school both emphasise the negative aspects of e-learning. Negative attitudes of students are also shown in the research by Lei et al. [53] for the statement that online laboratories can replace traditional ones.

The attitudes towards electrical and energy engineering students are also quite different from those of other students. They underline the positive aspects of e-learning, while compared to the vast majority of students in other study programs, they rate the negative aspects of e-learning less. These findings may confirm our assumption that students with more lectures and theoretical subjects saw the negative aspects to a lesser extent. It could also be concluded that teaching style [54], performances, and subject at first grade or teaching professors have influenced results. Stefanovic et al. [55] also point out that the flexibility and quality of an e-learning course strongly indicate student satisfaction.

Student residences. The results of our study have confirmed our initial assumption that there exist differences in attitudes between students who commute and those who reside in Novi Sad., which was in line with Al Rawashdeh et al. [10] finding that an e-learning system offers students active participation from any location or place. The flexibility of time and place are benefits of distance learning [13] that students in this research value more than the cost-effectiveness.

As can be seen, a significant difference related to the institutional support aspect appeared for the first time here between the opinions of travelling students and those living in or born in Novi Sad, in a way that the former evaluates this particular factor more positively than the latter. These findings may be hard to explain. One of the possible reasons for this result can be related to the statements concerning the organisation of online learning by the faculty. However, the schedule of classes during the week was organised so that students attended only online courses on certain days and had only experimental exercises on other days. In this sense, travelling students could stay at home several days a week and thus reduce the costs of studying. On the other hand, they had not been worried about whether they would make it to the online lectures immediately after the experimental exercises. Moreover, they could use their time on the way to the university by reviewing the accompanying materials that the professors uploaded to the platform.

Another reason may be related to the issue of communication, which appears in some items in this factor. Specifically, communication during the pandemic was difficult among students and professors, especially for those who did not live in the city and could not spend time with colleagues. For those students, the primary form of communication was through the platform, and it is possible that they evaluated these statements more positively than students who live in Novi Sad. Ismaili [56] also points out that most students favourably agreed that the faculty provided them with platforms for better communication with instructors.

Time spent on e-learning. Students' time on online learning is worth paying attention to successfully organised e-lectures. Our findings indicate that students who spent 5–7 hours on e-learning perceived more negative aspects of e-learning than students who spent 3–5 hours. Pikhart et al. [57] also point out that time spent in front of the computer is a drawback of online learning, considering that most students spend in front of the computer 6-12 hours. On the other hand, Bylieva et al. [58] found that students' time on e-learning was much less than expected. In any case, time spent in front of a computer is a crucial prerequisite for e-learning effectiveness. This study also revealed that students who spent 3–5 hours and 5–7 hours on e-learning perceived higher institutional support than those who consumed 1–3 hours. The latter may generally favour the traditional way of learning and prefer printed learning materials. Additionally, students who spent more than seven hours in lectures probably had more frequent problems with the Internet or technical issues and were eventually not satisfied with the lecture schedule. In any case, the results of this research imply that most students (70.6%) spent more than three and less than 5 hours daily on distance learning, while an estimated optimal number of hours spent on e-learning was 5–7 during the pandemic.

It is important to consider several potential limitations when interpreting the study results. The research relied on self-reported data from students, which may be subject to biases. The sample was drawn from only one university and

among first-grade students, which may limit the generalizability of the findings to the overall population. Additionally, the study had an unequal proportion of students among different groups and used a cross-sectional design, meaning that data was collected simultaneously. As a result, it may not be possible to draw causal inferences about the relationship between students' characteristics and their attitudes toward e-learning.

5. Conclusion

The study investigates engineering students' attitudes towards e-learning in hybrid environments, considering various socio-demographic factors. Results revealed that students' attitudes were influenced by high school background, previous experience with e-learning, teaching method, time spent on e-learning, study program, and students' residence.

Although regarding the advantages and disadvantages of e-learning, the results of this research align with previous ones. However, the authors found the students' attitudes interesting due to their study programs, i.e., course curriculum in higher school grades and first-year faculty. Students who attended face-to-face experimental and practical classes more often during the pandemic have a less favourable attitude towards e-learning than others. These results point to another disadvantage of e-learning, in addition to the previously established ones, indicating an existing gap in acquiring practical skills through e-learning. Moreover, e-learning is often praised for being time-efficient, but this study suggests that the amount of time required for e-learning may be a limitation. As a result, it is essential to carefully examine and determine the optimal length of time necessary for effective e-learning.

Additionally, the student's perspectives expressed through the survey showed that the faculty adapted exceptionally effectively to the newly created situation, i.e. teaching in emergency mode. This research also contributes to the existing results, confirming that educational institutions worldwide responded promptly and managed well during the pandemic. However, this study highlights the significance of institutional support, which has proved vital for non-urban students and students who spent more than 3 hours on e-learning.

Implications for further steps include integrating technology in teaching and learning, using data analytics to personalise learning, and developing new teaching methods and approaches to incorporate into learning platforms to fulfil all aspects of course requirements. Nonetheless, since the study programs investigated in this research are not accredited for distance learning, conclusive findings regarding the effectiveness of this learning approach cannot be drawn only based on this generation of students.

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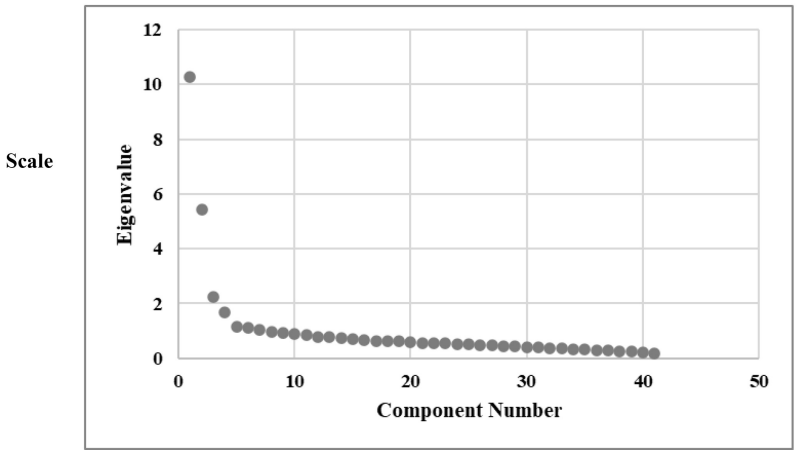
Appendix A.

Scree diagram on the 51 Students' Attitudes Towards E-learning Scale (SAES) items



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