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The Role of e-Learning Platforms in a Sustainable Higher Education: A Cross-Continental Analysis of Impact and Utility

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Abstract: The development of higher education worldwide must be integrated in the context of sustainable development in order to ensure environmental sustainability, social sustainability, and economic sustainability. Knowing that the digitalization process within higher education institutions is continuously expanding, while the digital tools and online learning environments enhance accessibility, flexibility, and efficiency, the purpose of the present paper is to highlight how the use of e-Learning platforms can help sustainable education development from the point of view of students from two universities: a university from Romania and a university from the USA. In order to reach this objective, a quantitative research method was used, aiming to identify the students' opinion on a series of facilities offered by e-Learning platforms that serve as the learning process. Data processing and analysis were conducted by means of specific tests supplied by the SPSS software. The obtained results showed that Moodle users spend approximately 26% more time on the platform than Blackboard users, with a small effect size (d = 0.284), while non-engineering students spend approximately 45% more time on the e-learning platform than engineering students, also with a small effect size (d = 0.458). The evaluation of the efficacy of different educational resources varies based on the e-learning platform used, with a large effect size found for editable files (d = 1.017) and PPT or similar formats (d = 1.2). Also, the efficacy of various applications on the e-learning platform varies by platform type, with a large effect size observed for two-way student–teacher communication (d = 0.819), self-assessment grid tests with immediate feedback (d = 1.072), synchronous online meetings with teachers (d = 1.117), and access to information from previous years (d = 0.89). We conclude that institutions should prioritize platform adaptability and student engagement strategies when implementing e-learning solutions for sustainable development.

Keywords: sustainable development; e-learning platforms; higher education; students; university

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1. Introduction

The transition to a more sustainable society can be greatly influenced by higher education institutions [1], as they play a key role in shaping future professionals and decision-makers. To guarantee environmental, social, and economic sustainability, higher education development must be incorporated into the framework of sustainable development on a global scale. According to Bygstad et al. [2], when it comes to digital transformation, universities should adopt a learning-centric approach, which entails creating a common learning area and combining organizational strategies, pedagogies, and technology. By fostering interactive and flexible learning environments, institutions enhance knowledge dissemination and equip students with the skills necessary for sustainable innovation. The COVID-19 crisis accelerated the development of the digital learning space [2,3], while the digitalization process within higher education institutions is continuously expanding.

New educational technologies play a crucial role in the teaching–learning process by granting students access to extensive resources and personalized learning materials. This increases their professional growth and enriches their entire educational experience [4]. E-learning platforms are increasingly vital in secondary and postsecondary education because of their numerous advantages, including accessibility, flexibility, tailored learning possibilities [5], and anytime or anywhere access [6,7]. Platforms such as Blackboard and Moodle can enhance student engagement and facilitate a hybrid learning approach [8].

A rise in e-learning platform usage and improved user satisfaction was identified after the pandemic, along with a decrease in reported technical issues. Additionally, a thematic analysis of student feedback revealed a predominantly positive sentiment among Transilvania University students [9]. These findings support the idea that e-learning in higher education is a sustainable approach, enhancing learning experiences beyond the pandemic.

The key advantage of e-learning over traditional distance learning is its interactive nature, which challenges common misconceptions about online education. Although virtual, e-learning programs captivate learners through elements such as online conferences, group discussions, and chat platforms, enhancing the experience's dynamism and engagement [6]. E-learning platforms have emerged to provide learning environments that enable students to study at their own speed as a consequence of improvements in educational technology. The availability of engaging experiences and the delivery of precise and prompt performance feedback are crucial for the success of these systems [10].

Despite the increasing use of e-learning platforms in higher education, there is a lack of comprehensive understanding regarding how different platforms impact student engagement, time spent on the platform, and the effectiveness of educational tools. This study aims to address the gap in knowledge by exploring how the type of e-learning platform influences student usage patterns, their perceptions of effectiveness, and the overall learning experience. Specifically, the research is focused on comparing student experiences with Moodle and Blackboard at two universities (one in Romania and one in the USA), while also examining differences between engineering and non-engineering students.

This research provides valuable insights into the role of digital learning in higher education and also for the development of e-learning platforms according to the needs of students across different educational and cultural backgrounds. E-learning plays a pivotal role in ensuring the sustainability of higher education, especially by enhancing accessibility and flexibility for students across diverse regions.

The novelty of the present study is related to the following aspects: (i) identifying cross-cultural insights into e-learning platform usage; (ii) efficacy evaluation of the educational resources according to the type of platform or student profile; (iii) efficacy evaluation of e-Learning applications according to the type of platform or student profile.

This study is significant, as it contributes to our understanding of the impact of different e-learning platforms (Moodle vs. Blackboard) on student engagement, learning experiences, and platform effectiveness in higher education. The results suggest that institutions should prioritize platform adaptability and student engagement strategies when adopting digital learning solutions to support sustainable education development. Choosing platforms that can be customized to meet the diverse needs of the students, along with promoting interactive and engaging learning environments, can enhance the overall educational experience. Additionally, the study highlights the importance of continuously evaluating the effectiveness of e-learning platforms and adjusting strategies to align with students' needs. This approach can lead to more efficient and inclusive learning, contributing to the long-term sustainability of higher education.

2. Literature Review

E-learning platforms may profoundly influence students' time management and learning engagement. Students engaged in online courses exhibit enhanced time management skills compared to their non-enrolled peers, with proficient users deriving greater advantages [11]. Students often embrace e-learning options, demonstrating favorable views toward platforms that facilitate language development [12]. The usefulness of e-learning systems is variable, as users experience challenges such as technical problems and insufficient instructor involvement [13]. Also, online learning effectiveness is influenced by factors such as the quality of digital tools, a good internet connection, and student motivation [14]. Notwithstanding these obstacles, e-learning systems have been shown to modestly enhance academic performance and effectively enable online evaluations [13].

One important factor in determining students' level and quality of learning is engagement, which has been linked to improvements in academic performance, persistence against dropping out, and cognitive and personal growth [15]. Considering the online environment, student involvement is directly proportional to performance and success [16]. Considering all these studies, the first hypothesis, H1, is as follows: the number of hours students spend engaging with the e-Learning platform varies based on platform type.

Studies demonstrate that student profiles considerably affect e-learning behaviors and results. Research indicates that examining online learner behavior might facilitate the development of individualized learning experiences and enhance instructional tactics [17,18]. Elements including learning disposition, engagement length, and emotional experiences in mathematics shape unique student profiles [17,19].

These profiles can be utilized to tailor e-learning content and guide both platforms and learners to enhance educational quality [17]. Moreover, research indicates differences in usage patterns and learning strategies between credit and noncredit learners on e-learning platforms [20]. Comprehending these various learner behaviors and reasons is vital for building effective e-learning resources that fulfill distinct student needs and goals [20]. This information may eventually enhance completion rates and overall learning outcomes in online education. The conclusion is thus the second hypothesis, H2: the amount of time students spend engaging with the e-Learning platform varies according to their individual profiles. Although e-learning platforms enhance time management skills [11] and students' performance improves overall as they spend more time online to access course materials, extra examples, notes, references, etc. [21], no direct comparisons exist in previous studies between Moodle and Blackboard or between engineering and non-engineering students.

The efficacy of e-learning tools is contingent upon the platform used and the attributes of the user. Various Learning Management Systems (LMS) may affect teaching efficacy, with characteristics such as instructor credentials and age impacting LMS proficiency [22]. The assessment of e-learning efficacy must take into account quantitative metrics, student achievement, and engagement analytics [23]. Some research indicates similar efficacy between e-learning and traditional techniques in medical education [24], while others reveal that online resources may markedly enhance knowledge and abilities relative to conventional training [25]. Nonetheless, there exists significant variability in the quality, design, and results of e-learning research studies. To improve e-learning effectiveness, it is essential to comprehend the fundamental characteristics of effective online resources and perform methodologically sound randomized controlled trials [25]. The third hypothesis, H3, considering all the above, is as follows: the evaluation of the efficacy of various educational materials varies according to the type of e-Learning platform used.

Moreover, student profiles and attributes substantially affect the efficacy of educational resources and learning results. Research indicates that students' interaction characteristics in adaptive and intelligent educational systems significantly influence their performance [26]. Yahiaoui et al. [3] showed that student motivation (attention, relevance, confidence, and satisfaction) and student outcomes (knowledge, skills, and attitudes) are significantly affected by e-Learning systems (technical and electronic requirements, personal requirements, perceived value, and credibility of e-Learning). The incorporation of student composition factors in value-added models might influence school performance metrics, underscoring the need for accounting for student context [27]. In blended learning contexts, students demonstrate varied patterns in their use of digital learning materials, attributable to individual variances in regulatory techniques [28]. Although students using diverse regulatory techniques may use learning resources similarly, the effect of these resources on academic achievement differs among student groups [28]. These results underscore the need for a more student-centered approach in educational design and the significance of contextualizing learning data to improve the quality of education for all students. As a conclusion, another hypothesis, namely H4, was formulated: the evaluation of the efficacy of various educational tools varies according to the student profile.

Studies demonstrate that the efficacy of e-learning platforms is contingent upon the platform type and user attributes. A comparative study of Blackboard, Google Classroom, and Zoom determined that Google Classroom was the most successful, followed by Blackboard and Zoom [29]. The Learning Management System (LMS) platform, as well as the credentials and age of the lecturer, might influence instructional efficacy [22]. Self-assessment instruments used inside e-learning platforms have shown considerable beneficial effects on student performance [30]. Assessing the operation of e-learning platforms is essential, given the significant variability in users' experiences and digital literacy levels [31]. These findings highlight the need to assess platform characteristics, user qualities, and assessment tools while implementing e-learning systems. Continuous evaluation and adjustment of e-learning platforms are crucial to ensure their effectiveness across diverse user demographics and educational contexts. The fifth hypothesis, H5, is as follows: the evaluation of the efficacy of certain applications on the e-Learning platform varies according to the platform type.

Also, the efficacy of e-learning platforms may differ based on student demographics. Latent profile analysis has identified three separate cohorts of students with varying opinions of e-learning quality [32]. Demographic variables, including age, field of study, and educational attainment, substantially influence the efficacy of e-learning [33]. Customized learning trajectories, developed by sophisticated algorithms and tailored to student profiles, may enhance e-learning results [34]. A study on a customized e-learning system revealed markedly improved outcomes for learners whose profiles informed the design of learning scenarios, especially among novice learners, minors, males, and individuals with elementary education [35]. The findings show that e-learning systems must be modified to fit diverse student backgrounds and learning styles to boost effectiveness, maybe employing intelligent algorithms and specialized content delivery approaches. Thus, the sixth hypothesis formulated, H6, is as follows: the evaluation of the efficacy of certain applications on the e-Learning platform varies according to the student profile.

The use of e-learning platforms in education provides flexibility and accommodates various learning styles, possibly enhancing educational results. Also, some studies [36,37] emphasize the importance of motivation for both students and teachers, highlighting the need for interactive technologies, timely feedback, and fostering a sense of community to create engaging and supportive online environments. However, research is needed to explore platform-specific differences and the impact of student profiles on e-learning effectiveness. By leveraging e-learning platforms, higher education institutions can significantly contribute to environmental sustainability, while improving accessibility and efficiency of the teaching–learning process. E-learning platforms provide a series of digital tools for both students and teachers that can support environmental, social, and economic sustainability. The most important benefits are (i) environmental protection and waste reduction through decreased travel, the replacement of textbooks and handouts with digital content, and energy consumption reduction; (ii) increased accessibility and inclusivity by allowing students to access educational resources from anywhere, thus ensuring continuous education without physical resources and serving a large number of students through effective course delivery; (iii) the promotion of sustainable practices among all the parties involved in the teaching–learning process by fostering worldwide collaboration among students and teachers from multiple countries, making them more aware of sustainable development.

3. Materials and Method

The research method used in the present paper was a survey, conducted between January 2024 and December 2024. The developed survey was tested on two important universities, one in Romania and one in the USA, aiming to conduct a cross-continental analysis of the impact and utility of e-learning platforms and their role in a sustainable learning process, with respect to higher education. The reason for choosing such a cross-continental analysis was the fact that the two universities use two of the most well-known e-learning platforms available today: Moodle, used by the university in Romania, and Blackboard, used by the university in the USA [38]. Moodle is mainly used in higher education in Europe, especially by state institutions, due to its open-source nature. Blackboard is widely used in the USA, especially by large universities and private universities.

3.1. Research Method and Representative Sample

The research developed by the means of the survey was based on two working instruments: a questionnaire was used as the data collection instrument and the SPSS software (version 20.0) was used as the data processing and analysis instrument [39]. The questionnaire was structured and contained 20 questions, arranged following a fixed interview scheme and grouped into five sections, as follows. The first part comprised a single question pertaining to the e-Learning platform used in the teaching–learning process, namely Moodle or Blackboard. The second part included a question emphasizing the estimated weekly hours students dedicate to the e-Learning platform. The final part comprised five questions about the efficacy of diverse educational tools and student preferences. The fourth part included 11 questions pertaining to the effectiveness of specific applications offered on the two e-Learning platforms. The concluding component comprised a single question prompting students to choose their profile: engineering or non-engineering, along with an inquiry about consent for the publication of the results. The questionnaire is included in Table A1 in Appendix A.

The questionnaire was original, created by the authors for this study. In order to prevent ambiguity and ensure that respondents understood the questions as intended, the questionnaire was developed in accordance with published recommendations for its design and the use of clear and succinct question phrasing [40]. To assess reliability, Cronbach's alpha was calculated, obtaining a value of 0.847, which suggests good internal consistency among the questions measuring the same construct.

The questionnaire was tested on two equal, independent samples (370 students from the university in Romania and 370 students from the university in the USA), resulting in a final representative sample of 740 students. This decision was based on the fact that the total number of students did not differ significantly from one university to the other, and the calculated samples had close values.

3.2. Statistical Analysis

Data processing and analysis were conducted using SPSS Statistics for Windows (version 20.0, IBM Corp., Armonk, NY, USA). The assumptions of normality and homogeneity of variance were verified with skewness, kurtosis, and Levene's test. Confirmation or refusal of the hypotheses was achieved with the help of the statistical *t*-test, considering the fact that the information underlying this research was obtained from two independent samples: the sample of students from the university in Romania and the sample of students from the university in the USA, both of which are large [41,42]. Cohen's (d) was used to estimate the effect size. The interpretation of the mentioned effect sizes was as follows: very small ($d < 0.2$), small ($0.2 \leq d < 0.5$), medium ($0.5 \leq d < 0.8$), and large ($d \geq 0.8$) [43]. The significance level for all comparisons was set to $p < 0.05$.

The research conducted in this paper was based on six hypotheses, as follows:

H_1: *The number of hours students spend engaging with the e-Learning platform varies based on the platform type.*

H_2: *The amount of time students spend engaging with the e-Learning platform varies according to their profiles.*

H_3: *The evaluation of the efficacy of various educational resources varies according to the type of e-Learning platform used.*

H_4: *The evaluation of the efficacy of various educational resources varies according to the student profile.*

H_5: *The evaluation of the efficacy of certain applications available on the e-Learning platform varies according to the platform type.*

H_6: *The evaluation of the efficacy of certain applications available on the e-Learning platform varies according to the student profile.*

4. Results

The results obtained from the research carried out within this paper were used to either accept or reject the hypotheses previously formulated.

The results concerning the testing of hypotheses H_1 and H_2 are presented in Tables 1–3.

Table 1. Comparison of means for hypotheses H_1 and H_2.

	Platform	N	X	SD	d	SP	N	X	SD	d
Time (hours per week)	Moodle	370	4.90	4.62	0.284	Eng	345	3.70	2.81	0.458
	Blackboard	370	3.88	2.08		Non-eng	305	5.38	4.35	

N—number of responses, X—average, SD—standard deviation, SP—student profile, Eng—engineering, Non-eng—non-engineering, d—effect size.

In Table 2, it can be seen that there are two lines containing results. In order to identify the line from which the results should be read, two other hypotheses must be formulated: H_0—the two groups (the student group using Moodle and the student group using Blackboard) are homogeneous, meaning that equal variances are assumed, and H_1—the two groups are heterogeneous, meaning equal variances are not assumed. The decision to choose between H_0 and H_1 is made according to the result of the Levene's test, in the first part of Table 2. It is observed that the value of *p* is lower than the theoretical value of 0.05. Therefore, the H_1 hypothesis is confirmed, and the result of the *t*-test is read from the second line (the one colored in gray). These explanations are also valid for the following tables, with the gray color indicating the line from which the results should be read.

Table 2. Independent sample test for hypothesis H_1.

		LT		*t*-Test for Equality of Means					
		F	*p*	t	df	*p*	DX	CI95% Lower	CI95% Upper
Time (hours per week)	EVA	50.561	≤0.001	3.879	738	≤0.001	1.022	0.505	1.540
	EVNA			3.879	513.1	≤0.001	1.002	0.504	1.541

LT—Levene's test for equality of variances, F—Levene's test F-value, *p*—significant level of probability, df—degrees of freedom, DX—average difference, CI—interval of confidence, EVA—equal variances assumed, EVNA—equal variances not assumed. The gray line indicates where the results should be read from.

Table 3. Independent sample test for hypothesis H_2.

		LT		*t*-Test for Equality of Means					
		F	*p*	t	df	*p*	DX	CI95% Lower	CI95% Upper
Time (hours per week)	EVA	17.596	≤0.001	−6.372	738	≤0.001	−1.679	−2.196	−1.161
	EVNA			−5.927	479.175	≤0.001	−1.679	−2.235	−1.122

LT—Levene's test for equality of variances, F—Levene's test F-value, *p*—significant level of probability, df—degrees of freedom, DX—average difference, CI—interval of confidence, EVA—equal variances assumed, EVNA—equal variances not assumed. The gray line indicates where the results should be read from.

The results concerning the testing of hypotheses H_3 and H_4 are presented in Tables 4–6.

Table 4. Comparison of means for hypotheses H_3 and H_4.

Educational Resource	Platform	N	X	SD	d	SP	N	X	SD	d
PDF	Moodle Blackboard	370 370	4.02 3.25	1.05 1.40	0.622	Eng Non-eng	435 305	3.72 3.52	1.23 1.37	0.153
Editable file	Moodle Blackboard	370 370	3.80 2.68	0.98 1.21	1.017	Eng Non-eng	435 305	3.31 3.13	1.19 1.30	0.144
PPT or similar	Moodle Blackboard	370 370	3.99 2.62	1.08 1.20	1.20	Eng Non-eng	435 305	3.33 3.27	1.30 1.37	0.044
HTML	Moodle Blackboard	370 370	2.96 3.04	2.46 0.87	0.043	Eng Non-eng	435 305	2.89 3.15	1.07 2.57	0.132
Digital	Moodle Blackboard	370 370	3.92 4.05	1.12 1.02	0.121	Eng Non-eng	435 305	3.97 4.00	1.16 0.94	0.028

N—number of responses, X—average, SD—standard deviation, SP—student profile, Eng—engineering, Non-eng—non-engineering, d—effect size.

Table 5. Independent sample test for hypothesis H_3.

		LT		*t*-Test for Equality of Means					
		F	*p*	t	df	*p*	DX	CI95% Lower	CI95% Upper
PDF	EVA	74.904	≤0.001	8.396	738	≤0.001	0.765	0.586	0.944
	EVNA				683.7	≤0.001	0.765	0.586	0.944

Table 5. *Cont.*

		LT		*t*-Test for Equality of Means					
		F	***p***	**t**	**df**	***p***	**DX**	**CI95% Lower**	**CI95% Upper**
Editable	EVA	27.936	≤0.001	13.838	738	≤0.001	1.127	0.967	1.287
	EVNA			13.838	708.5	≤0.001	1.127	0.967	1.287
PPT	EVA	24.897	≤0.001	16.374	738	≤0.001	1.387	1.213	1.544
	EVNA			16.374	730.2	≤0.001	1.378	1.213	1.544
HTML	EVA	12.619	≤0.001	−0.557	738	0.578	−0.076	−0.343	0.191
	EVNA			−0.557	460.9	0.578	−0.076	−0.343	0.191
Digital	EVA	1.142	0.286	−1.571	738	0.117	−0.124	−0.280	0.031
	EVNA			−1.571	731.8	0.117	−0.124	−0.280	0.031

LT—Levene's test for equality of variances, F—Levene's test F-value, *p*—significant level of probability, df—degrees of freedom, DX—average difference, CI—interval of confidence, EVA—equal variances assumed, EVNA—equal variances not assumed. The gray line indicates where the results should be read from.

Table 6. Independent sample test for hypothesis H_4.

		LT		*t*-Test for Equality of Means					
		F	***p***	**t**	**df**	***p***	**DX**	**CI95% Lower**	**CI95% Upper**
PDF	EVA	10.238	0.001	2.087	738	0.037	0.202	0.012	0.391
	EVNA			2.046	606.849	0.041	0.202	0.008	0.395
Editable	EVA	3.192	0.074	1.985	738	0.048	0.184	0.002	0.366
	EVNA			1.955	618.397	0.051	0.184	−0.001	0.368
PPT	EVA	0.119	0.730	0.623	738	0.533	0.062	−0.134	0.258
	EVNA			0.617	633.009	0.537	0.062	−0.136	0.260
HTML	EVA	0.594	0.441	−1.903	738	0.057	−0.262	−0.533	0.008
	EVNA			−1.680	379.153	0.094	−0.262	−0.569	0.045
Digital	EVA	8.391	0.004	−0.412	738	0.681	−0.033	−0.191	0.125
	EVNA			−0.427	721.047	0.670	−0.033	−0.186	0.119

LT—Levene's test for equality of variances, F—Levene's test F-value, *p*—significant level of probability, df—degrees of freedom, DX—average difference, CI—interval of confidence, EVA—equal variances assumed, EVNA—equal variances not assumed. The gray line indicates where the results should be read from.

The results concerning the testing of hypotheses H_5 and H_6 are presented in Tables 7–9.

Table 7. Comparison of means for hypotheses H_5 and H_6.

e-Learning Applications	Platform	N	X	SD	d	SP	N	X	SD	d
Access to resources	Moodle Blackboard	370 370	4.50 4.74	0.80 0.52	0.355	Eng Non-eng	435 305	4.60 4.65	0.74 0.60	0.074
Setting up your profile	Moodle Blackboard	370 370	4.37 4.21	0.88 1.05	0.165	Eng Non-eng	435 305	4.35 4.20	0.95 0.99	0.154
Two-way student–teacher communication	Moodle Blackboard	370 370	4.02 3.09	1.03 1.23	0.819	Eng Non-eng	435 305	3.66 3.41	1.22 1.22	0.204
Communication with teachers and colleagues	Moodle Blackboard	370 370	3.63 2.92	1.19 1.35	0.557	Eng Non-eng	435 305	3.39 3.11	1.34 1.28	0.213
Uploading projects, homework, or reports	Moodle Blackboard	370 370	4.51 4.10	0.82 1.10	0.422	Eng Non-eng	435 305	4.32 4.28	0.89 1.11	0.039

Table 7. *Cont.*

e-Learning Applications	Platform	N	X	SD	d	SP	N	X	SD	d
Feedback from the teacher	Moodle Blackboard	370 370	4.03 4.15	1.05 1.23	0.104	Eng Non-eng	435 305	4.06 4.14	1.23 1.01	0.071
Taking exams in the form of grid tests	Moodle Blackboard	370 370	4.28 3.65	1.08 1.31	0.524	Eng Non-eng	435 305	4.12 3.74	1.17 1.30	0.307
Self-assessment grid tests with immediate feedback	Moodle Blackboard	370 370	4.50 3.37	0.78 1.27	1.072	Eng Non-eng	435 305	4.09 3.70	1.19 1.18	0.329
Grade book	Moodle Blackboard	370 370	4.33 3.73	0.96 1.20	0.552	Eng Non-eng	435 305	3.99 4.09	1.16 1.07	0.089
Synchronous online meetings with teachers	Moodle Blackboard	370 370	4.04 2.76	1.10 1.19	1.117	Eng Non-eng	435 305	3.62 3.09	1.26 1.33	0.409
Access to information from previous years	Moodle Blackboard	370 370	3.96 2.87	1.12 1.32	0.890	Eng Non-eng	435 305	3.59 3.17	1.34 1.31	0.316

N—number of responses, X—average, SD—standard deviation, SP—student profile, Eng—engineering, Non-eng—non-engineering, d—effect size.

Table 8. Independent sample test for hypothesis H_5.

		LT		*t*−Test for Equality of Means					
		F	*p*	t	df	*p*	DX	CI95% Lower	CI95% Upper
Access to resources	EVA	72.678	≤0.001	−4.895	738	≤0.001	−0.243	−0.341	−0.146
	EVNA			−4.895	634.8	≤0.001	−0.243	−0.341	−0.146
Setting up your profile	EVA	6.822	0.009	2.232	738	0.026	0.159	0.019	0.300
	EVNA			2.232	715	0.026	0.159	0.019	0.300
Two-way student−teacher communication	EVA	7.586	0.006	11.068	738	≤0.001	0.927	0.763	1.091
	EVNA			11.068	714.9	≤0.001	0.927	0.763	1.091
Communication with teachers and colleagues	EVA	5.085	0.024	7.528	738	≤0.001	0.708	0.523	0.893
	EVNA			7.528	726.6	≤0.001	0.708	0.523	0.893
Uploading projects, homework, or reports	EVA	12.435	≤0.001	5.722	738	≤0.001	0.408	0.268	0.548
	EVNA			5.722	682.7	≤0.001	0.408	0.268	0.548
Feedback from the teacher	EVA	8.807	0.003	−1.443	738	0.150	−0.122	−0.287	0.044
	EVNA			−1.443	721	0.150	−0.122	−0.287	0.044
Taking exams in the form of grid tests	EVA	54.134	≤0.001	7.127	738	≤0.001	0.632	0.458	0.807
	EVNA			7.127	710.9	≤0.001	0.632	0.458	0.807
Self-assessment grid tests with immediate feedback	EVA	113.896	≤0.001	14.537	738	≤0.001	1.132	0.980	1.285
	EVNA			14.537	612.2	≤0.001	1.132	0.979	1.285
Grade book	EVA	30.076	≤0.001	7.456	738	≤0.001	0.597	0.440	0.755
	EVNA			7.456	703.9	≤0.001	0.597	0.440	0.755
Synchronous online meetings with teachers	EVA	8.138	0.004	15.081	738	≤0.001	1.276	1.110	1.442
	EVNA			15.081	733.9	≤0.001	1.276	1.110	1.442
Access to information from previous years	EVA	27.841	≤0.001	12.105	738	≤0.001	1.095	0.917	1.272
	EVNA			12.105	719.4	≤0.001	1.095	0.917	1.272

LT—Levene's test for equality of variances, F—Levene's test F-value, *p*—significant level of probability, df—degrees of freedom, DX—average difference, CI—interval of confidence, EVA—equal variances assumed, EVNA—equal variances not assumed. The gray line indicates where the results should be read from.

Table 9. Independent sample test for hypothesis H_6.

		LT		*t*-Test for Equality of Means					
		F	***p***	**t**	**df**	***p***	**DX**	**CI95% Lower**	**CI95% Upper**
Access to resources	EVA	5.476	0.020	−0.915	738	0.361	−0.047	−0.148	0.054
	EVNA			−0.949	722.7	0.343	−0.047	−0.144	0.050
Setting up your profile	EVA	0.011	0.918	2.058	738	0.040	0.149	0.007	0.292
	EVNA			2.041	635.5	0.042	0.149	0.006	0.293
Two-way student–teacher communication	EVA	0.074	0.785	2.771	738	0.006	0.253	0.074	0.433
	EVNA			2.772	655.6	0.006	0.253	0.074	0.433
Communication with teachers and colleagues	EVA	5.401	0.020	2.842	738	0.005	0.280	0.087	0.474
	EVNA			2.866	672.7	0.004	0.280	0.088	0.472
Uploading projects, homework, or reports	EVA	1.825	0.177	0.570	738	0.569	0.042	−0.103	0.187
	EVNA			0.549	562.7	0.583	0.042	−0.109	0.193
Feedback from the teacher	EVA	12.304	≤0.001	−1.001	738	0.317	−0.086	−0.254	0.082
	EVNA			−1.036	719.1	0.301	−0.086	−0.248	0.077
Taking exams in the form of grid tests	EVA	10.114	0.002	4.134	738	≤0.001	0.381	0.200	0.562
	EVNA			4.059	609.8	≤0.001	0.381	0.197	0.565
Self-assessment grid tests with immediate feedback	EVA	2.024	0.155	4.395	738	≤0.001	0.389	0.215	0.563
	EVNA			4.401	657.9	≤0.001	0.389	0.216	0.563
Grade book	EVA	1.564	0.211	−1.225	738	0.221	−0.103	−0.269	0.062
	EVNA			−1.242	683.5	0.215	−0.103	−0.267	0.060
Synchronous online meetings with teachers	EVA	0.893	0.345	5.490	738	≤0.001	0.529	0.340	0.718
	EVNA			5.440	632.3	≤0.001	0.529	0.338	0.720
Access to information from previous years	EVA	0.327	0.568	4.173	738	≤0.001	0.415	0.220	0.610
	EVNA			4.190	663.7	≤0.001	0.415	0.220	0.609

LT—Levene's test for equality of variances, F—Levene's test F-value, *p*—significant level of probability, df—degrees of freedom, DX—average difference, CI—interval of confidence, EVA—equal variances assumed, EVNA—equal variances not assumed. The gray line indicates where the results should be read from.

5. Discussion

The present study investigates the students' use and perception of e-learning platforms in the teaching–learning process. The research focuses on comparing student experiences with Moodle and Blackboard at two universities (one in Romania and one in the USA), while also examining differences between engineering and non-engineering students.

With respect to hypotheses H_1 and H_2, both are accepted, since the *p*-values from Tables 2 and 3 are lower than the theoretical value of 0.05, indicating that the time spent by students engaging with the e-learning platforms varies according to the platform type and student profile. Thus, Table 1 highlights that students using the Moodle platform spend approximately 26% more time on the platform, with an average time of 4.9 h per week, compared to students using the Blackboard platform, who spend an average of 3.88 h per week. The effect size is small (d = 0.284), suggesting that, while students using Moodle spend more time on the platform than those using Blackboard, the difference is not substantial enough to indicate a major practical advantage. This implies that other factors, such as usability, engagement, or learning effectiveness, should be considered when evaluating the overall impact of the platform choice. The same table also indicates that non-engineering students spend approximately 45% more time on the e-learning platform, with an average of 5.38 h per week, compared to engineering students, who spend an average of 3.70 h per week. The effect size is also small (d = 0.458), suggesting that non-engineering courses may require more online engagement due to their structure, learning activities, or assessment methods, whereas engineering students might rely more on offline resources, hands-on work, or laboratory sessions. Although e-learning platforms enhance time management skills [11] and students' performance improves as they spend more time online to access course materials, extra examples, notes, references, etc. [21], no direct comparisons exist in previous studies between Moodle and Blackboard or engineering and non-engineering students.

Concerning hypotheses H_3 and H_4, the results present the following aspects. Hypothesis H_3 is accepted with respect to PDFs, editable files, and PPT types of educational resources (circled in Figure 1). Regarding the other two types of educational resources (HTML and digital), hypothesis H_3 is rejected, as Table 5 indicates. A large effect size was found for editable files (d = 1.017) and PPT or similar (d = 1.2), while for PDFs a medium effect was obtained (d = 0.622). The strong preference for editable files and presentations may indicate that students value interactive and flexible content that allows for customization and easier comprehension. In contrast, PDFs, while still effective, may be perceived as more static and less engaging. For the other resources, the effect size was small. These findings highlight the importance of choosing the right content format to enhance e-learning adoption and effectiveness. Figure 1 highlights the types of educational resources that are preferred by students and the types that are less preferred according to the type of e-learning platform.

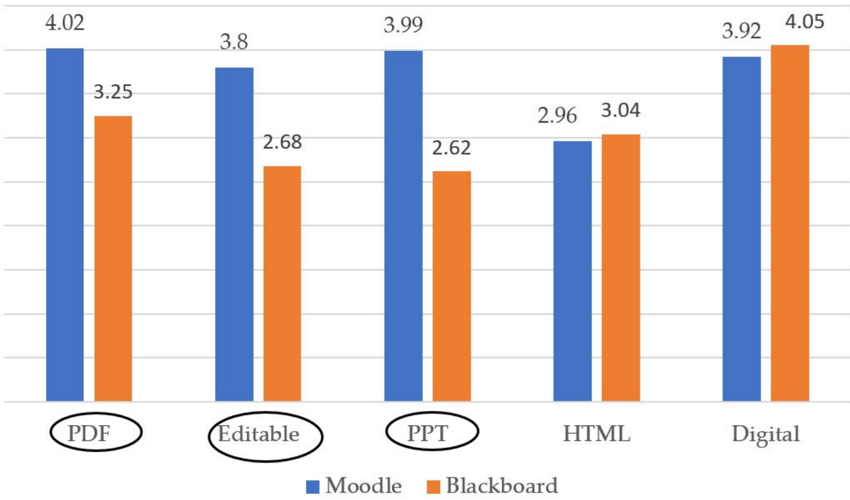

Figure 1. Preferences for educational resource types according to the e-learning platform type.

As Figure 1 indicates, in the case of the first three types of educational resources (in which case hypothesis H_3 was accepted), they are preferred by students using Moodle. The HTML format is the least preferred by students using both platforms, while the digital format is the most preferred by students using both platforms.

Hypothesis H_4 is accepted in the case of PDFs and editable types of resources (circled in Figure 2), while it is rejected in the case of other types of resources (PPT, HTML, and digital), in accordance with the results from Table 6. The small effect size across all resource types suggests that, although certain formats are preferred, the differences in student engagement or usage are not substantial enough to indicate a strong practical impact. Figure 2 presents the types of educational resources that are more preferred by students and those that are less preferred, according to the student profile.

As it can be seen in Figure 2, the most preferred type of educational resources is the digital one, favored by both engineering and non-engineering students, while the HTML format is the least preferred by students from both profiles. These findings highlight the importance of a student-centered design in e-learning and the need to contextualize learning data to enhance educational quality, a finding that is in line with previous studies [27,28].

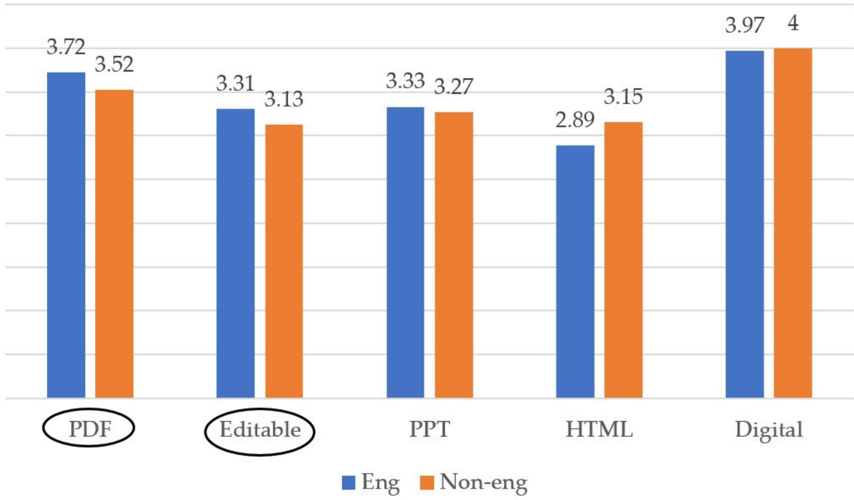

Figure 2. Preferences for educational resource types according to the student profile.

With regard to hypotheses H_5 and H_6, the following conclusions can be drawn according to the results in Table 8. Hypothesis H_5 is confirmed (*p*-value is lower than 0.05) in the case of the following applications on the e-learning platform: access to educational resources, setting up the profile, two-way teacher–student communication, communication with colleagues and teachers, uploading projects, homework, or reports, grid test exams and self-assessment grid tests with immediate feedback, grade book, synchronous online meetings with teachers, and access to information from previous years. Hypothesis H_5 is rejected in the case of feedback from teachers. The most significant difference between the two platforms with respect to e-learning applications are as follows: two-way student–teacher communication (DX = 0.927), communication with teachers and colleagues (DX = 0.708), self-assessment grid tests with immediate feedback (DX = 1.132), synchronous online meetings with teachers (DX = 1.276), and access to information from previous years (DX = 1.095).

The statistical indicator Cohen's for the effect size of both Moodle and Blackboard samples showed a large effect size for two-way student–teacher communication, (d = 0.819), self-assessment grid tests with immediate feedback (d = 1.072), synchronous online meetings with teachers (d = 1.117), and access to information from previous years (d = 0.89). This result suggests that these features have a substantial impact on student engagement and learning effectiveness. A medium effect size was obtained for communication with teachers and colleagues, taking exams in the form of grid tests, and the grade book, indicating that, while these features are important, their impact is less pronounced compared to the high-effect-size elements.

Figure 3 indicates the platform applications that students consider more efficient and those that they consider less efficient, according to the type of e-learning platform. The applications for which hypothesis H_5 is accepted are underlined.

As Figure 3 presents, many of the e-learning platform applications received scores higher than 4, meaning that students consider them efficient. Applications such as: communications with colleagues, online meetings and access to information from previous years are considered less efficient, having scores of 2.92, 2.76 and 2.87, respectively. An interesting aspect is that students using Moodle consider all the platform applications more efficient than students using Backboard. Nevertheless, ref. [44] emphasized that interactive elements such as discussion boards and group projects that facilitate face-to-face communication must be incorporated into online education. These findings suggest that improving the interactivity of such applications could increase their perceived efficiency among students.

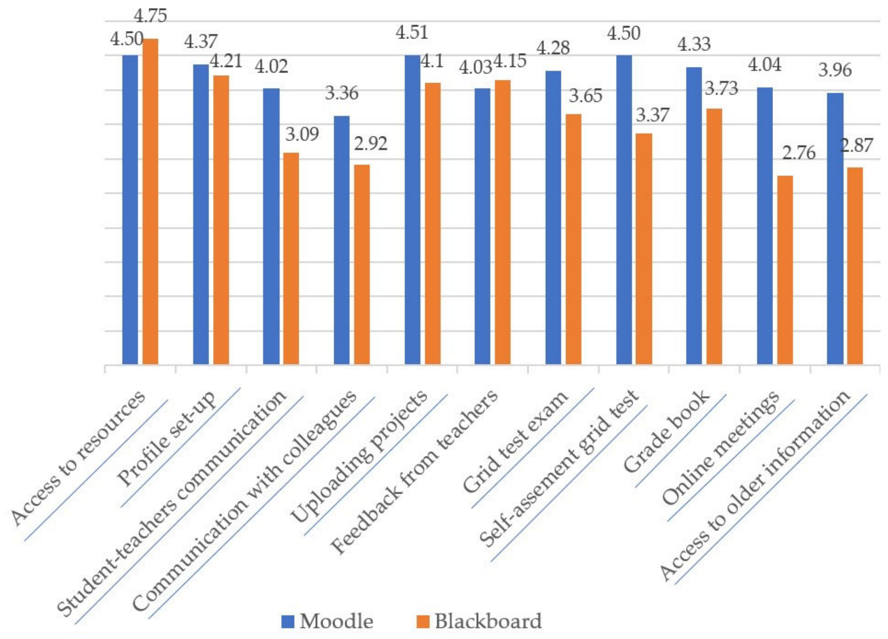

Figure 3. Assessment of the efficiency of the e-learning applications according to the platform type.

Hypothesis H_6 is accepted in case of the following e-learning platform applications: setting up the student profile, two-way student teacher communication, communication with teachers and colleagues, grid test exams, self-assessment tests, online meetings with teachers and access to information from previous years (as they are underlined in Figure 4). In case of the other platform applications (access to educational resources, uploading projects, feedback from teachers and the grade book) the hypothesis is rejected.

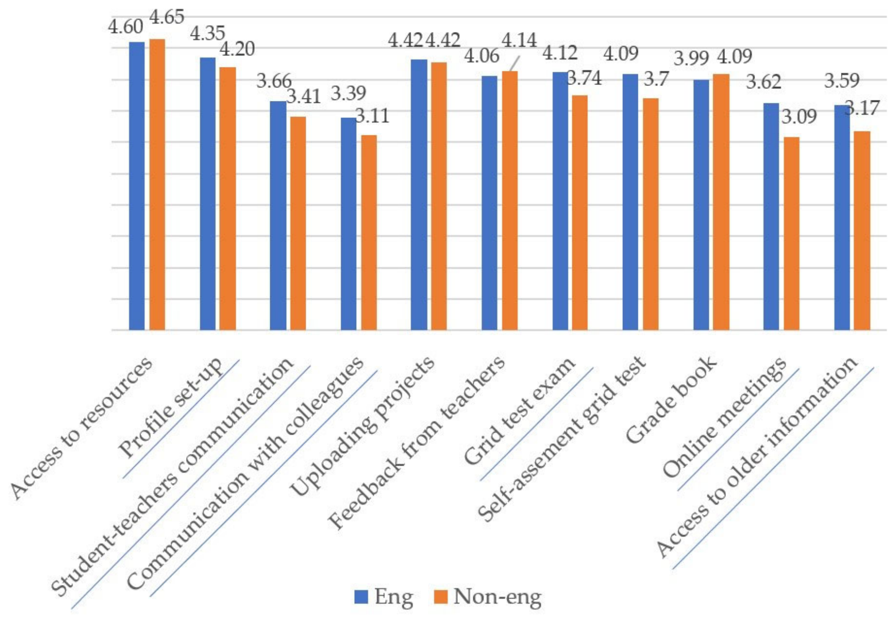

Figure 4. Assessment of the efficiency of the e-learning applications according to the student profile.

The effect size between engineering and non-engineering students related to e-learning applications is medium for two-way student-teacher communication, communication with teachers and colleagues, taking exams in the form of grid tests, self-assessment grid tests with immediate feedback, synchronous online meetings with teachers and access to information from previous years. This indicates that while there are notable differences between the two student groups in how they engage with these features, the impact is moderate rather than substantial. For all other variables, the effect size is small, suggesting that the differences in e-learning preferences and behaviors between engineering and non-engineering students in these areas are less significant.

Figure 4 illustrates how the students ranked the e-learning platform applications, according to their profile.

As Figure 4 highlights, the e-learning platform considered to be the most efficient by both engineering and non-engineering students is access to educational resources, followed by uploading projects and other materials and feedback from teachers. Setting up the profile is also considered very efficient, especially by engineering students. Blackboard and Moodle provide advanced communication tools, including forums and chats, as well as extensive assessment features like quizzes and online exams [6].

As the results illustrate, there are certain differences between engineering and non-engineering students with respect to the use of the tools provided by the e-learning platforms. Engineering students spend more time on the e-learning platform than non-engineering students. One possible explanation would be that the subjects in the engineering students' curriculum are more application-oriented, and the subjects of non-engineering students are more descriptive. That is why, as identified, engineering students appreciate html or digital educational resources more, while non-engineering students prefer educational resources in doc, pdf, or PPT formats. Also, according to the scores obtained by the e-learning tools, they obtained higher values in the case of engineering students than in the case of non-engineering students. Therefore, engineering students regard the e-learning platform tools as being more efficient compared to non-engineering students. This could be explained by the fact that engineering students have better developed digital skills than non-engineering students, with engineering students using the e-learning platform more easily, exploiting it in a more efficient manner than non-engineering students do. The results also indicate that students using Moodle assigned higher scores with respect to the efficiency of e-learning platform tools than students using Blackboard. Students' perception of the effectiveness of the Moodle versus Blackboard tools can be justified by the platform's flexibility, intuitive interface, accessibility, and level of customization. Moodle allows for a more tailored learning experience, with students finding it more effective compared to Blackboard. The results obtained by the study developed in the present paper represent a solid base for the decisional factors in higher institutions with respect to choosing the proper digital tools and e-learning platforms in the teaching–learning process. As students' requirements and needs are continuously changing as a result of societal and technological evolution, the digital tools must adjust to these needs in order to support, in the best way possible, environmental, social, and economic sustainability in higher education. E-learning platforms can help the natural environment by reducing pollution, social sustainability by allowing a large number of students to access educational resources, and they might also support economic sustainability by allowing universities to benefit from the same financial resources.

These findings reinforce the importance of customizing e-learning platforms to fit both platform characteristics and student demographics, potentially integrating adaptive learning algorithms to optimize engagement and performance. In order to make the lesson accessible, useful, and responsive to the needs of the students, e-learning design must incorporate well-managed resources [45]. This includes offering user-friendly navigation, interesting content and activities, interactive games (educational games), textual feedback, and encouraging the use of visual and auditory stimuli [45].

There are certain limitations in this study that should be taken into account in subsequent research. First, the research is based on students from only two universities, one in Romania and one in the United States, which may not fully represent the experiences of students from other institutions or regions. Furthermore, cultural and educational disparities between the two nations, including variation in pedagogical approaches, institutional regulations, and digital literacy, may affect students' impressions of e-learning platforms, making direct comparisons more challenging. Future studies should consider incorporating a wider range of universities from different regions to ensure a more global and comprehensive understanding of e-learning platforms' impact.

Another limitation is that the study relies on self-reported data, which can be subjective and influenced by personal biases or recall inaccuracies. Moreover, the focus is solely on Moodle and Blackboard, excluding other widely used e-learning platforms like Google Classroom, Canvas, or Microsoft Teams, an approach which might limit the applicability of the results to different educational settings. Future research could broaden the scope by examining a wider array of e-learning platforms, especially those that are gaining popularity in various educational contexts, to better understand the comparative effectiveness of different tools in diverse institutional environments.

Furthermore, the study provides a snapshot of students' experiences at a specific point in time, without tracking changes in their perceptions or behaviors over a longer period. This lack of longitudinal analysis prevents an understanding of how students' engagement with e-learning platforms evolves. Future research could follow cohorts of students throughout a full academic year or more to examine how their experiences with e-learning platforms evolve as they gain more experience, and as educational technology continues to develop.

However, to better understand what has to be improved in e-learning platforms, further research is required. Understanding how the complexity of course materials influences student engagement and learning outcomes can help educators develop more adaptive and accessible digital resources. Investigating student motivation—both intrinsic and extrinsic—can provide insights into strategies for improving participation, retention, and overall learning effectiveness in online education. Additionally, future studies should explore the long-term impact of e-learning on educational sustainability, including its effects on resource efficiency, student engagement, and academic performance. Examining how digital learning reduces reliance on physical resources, such as printed materials and classroom infrastructure, while also addressing potential challenges like energy consumption and data storage sustainability, would contribute to a more holistic understanding of its environmental impact.

6. Conclusions

This research presents a comparative examination of the impact and efficacy of e-learning systems in higher education, focusing on Moodle and Blackboard. The study, conducted via a cross-continental survey of students from Romania and the USA, indicates that both platform type and student profile strongly impact engagement patterns, resource choices, and perceived platform efficiency.

The obtained results revealed the following:

- Moodle users spend more time on the platform compared to Blackboard users.
- Non-engineering students dedicate more time to e-learning platforms than engineering students.
- PDF, editable, and PPT formats are more preferred by Moodle users, while digital resources are the most favored by all students, regardless of the platform.
- HTML resources are the least favored by students.
- Moodle users usually rate all apps more positively in terms of efficiency compared to Blackboard users.

- Applications such as two-way teacher–student contact, uploading work, and self-assessment examinations are greatly appreciated, although online meetings and access to prior materials are viewed as being less beneficial.
- Engineering students prioritize structured features such as profile setup and assessment tools, while non-engineering students value teacher–student communication and feedback more.

Overall, the study underscores the need for e-learning platforms to be tailored to the specific needs of different student groups. The results suggest that institutions should consider platform adaptability and student engagement strategies when implementing e-learning solutions for sustainable development. Future research should explore additional factors, such as course content complexity, student motivation, and institutional digital strategies, to further enhance the effectiveness of e-learning in higher education.

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Institutional Review Board Statement: The study was conducted according to the guidelines of the Declaration of Helsinki and approved by the Council of the Faculty of Technological Engineering and Industrial Management from the Transilvania University of Brasov, Romania, agreement number 1755 from 13 May 2024.

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: The data used to support the findings of the current study are available from the corresponding authors upon request.

Conflicts of Interest: The authors declare no conflicts of interest.

Appendix A

Table A1. Questionnaire.

1.	What platform do you use in your teaching activities at the faculty you attend? Moodle Blackboard
2.	Approximately how many hours do you spend per week on the e-Learning platform?
	What type of educational resource do you prefer considering its efficiency with respect to the learning process?
3 **.	PDF
4 **.	Editable file
5 **.	PPT or similar
6 **.	HTML resource
7 **.	Digital resource (video and audio included)
8 *.	Access to teaching materials uploaded by teachers on the e-Learning platform is very easy.
9 *.	Setting up your profile on the e-Learning platform is very simple.
10 *.	Two-way student–teacher communication on the e-Learning platform is very simple and efficient.

Table A1. *Cont.*

11 *.	Communication with teachers and colleagues via the forum is very effective.
12 *.	Uploading projects, homework, or reports onto the e-Learning platform is quick and easy.
13 *.	Feedback from the teacher on projects, homework, or reports is quick and can be detailed.
14 *.	Taking exams in the form of grid tests on the e-Learning platform is very effective.
15 *.	Self-assessment grid tests with immediate feedback are very effective.
16 *.	The grade book available on the e-Learning platform allows you to view the grades received for all activities in the subject (seminar, lab, project) and how the final grade was calculated.
17 *.	The e-Learning platform enables synchronous online meetings with teachers.
18 *.	Access to information from previous years is possible and easy.
19.	Profile Engineering Non-engineering
20.	Agreement for result publishing Yes No

* 5—totally agree; 1—not at all agree. ** 5—very efficient; 1—very inefficient.

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