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Digital skills impact on university students' academic performance: An empirical investigation

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Abstract: E-learning adoption strategies are rising alongside the growth and accessibility of e-learning technologies that cater to the needs of a diverse range of learners. Meanwhile, most e-learning models and approaches try to find the optimal match between e-learning components and the determinants for enhancing e-learning and learner performance. Learners' digital skills are important determinants for e-learning success, which was not widely tested in prior research. Therefore, this paper aims to provide further insight into digital skills and their impact on students' performance in the e-learning system. A comprehensive model was proposed incorporating digital skills dimensions (common digital skills, educational digital skills, and advanced digital skills) as independent variables and students' academic performance (academic effectiveness, academic efficiency, academic satisfaction) as dependent variables, and data were collected from university students. After that, the study hypotheses and model were tested using regression analysis. The results reveal that the respondents possess satisfying common and educational digital skills, and less advanced digital skills. While their academic effectiveness and efficiency meet expectations, and their academic satisfaction is moderate. In addition, the findings show that the regression analysis supports the hypothesized relationships between independent and dependent variables in the research model; where digital skills dimensions positively impact students' academic performance. Specifically, the results indicate that achieving the highest student academic performance requires a combination of digital skills application to be possessed by those students; mainly common digital communicating and application skills, educational digital problem-solving skills, digital safety skills, educational information and data processing skills, and some aspects of advanced digital skills such as application applications development, augmented reality, and database management systems. These results support the research model and show that this model provides good explanations for the variance in the student's academic performance. In addition, this study recommends further questions for more independent variables that may impact a student's academic performance dimensions.

Keywords: *Academic Performance, Digital Skills Measures, Digital Skills, E-Learning.*

1. Introduction

It's reported that [1, 2, 3] in today's rapidly evolving digital landscape; evolving global workforce dynamics, rapid technological advancements, and rising remote and hybrid work models, digital transformation becomes a necessity for businesses to remain competitive and relevant. Digital skills provide tremendous economic value for businesses and workers worldwide, raising GDP, revenue growth, innovation, wages, job security, and job satisfaction. Furthermore, statistical market reports [1, 3] show that the global workplace digital transformation market was valued at USD 19 billion in 2022, and USD 29.8 Billion in 2023, with an expected growth rate (CAGR) of 12% during 2024-2032.

Meanwhile, it's reported [4, 5, 6, 7] that there is a gap between the existing and needed digital skills to respond to the challenges of the digitalized workplace in the future; where [8, 9] the lack

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of digital skills, knowledge, and expertise and experience are the major barriers which affect the individual's and firm's performance. Thus, governments, businesses, and educational institutions [10, 11] need to collaborate and make significant investments to address the digital skills crisis; the gap between the necessary and available digital skills.

On the other side, the raised adoption of e-learning strategies, higher education sector growth, increased lifelong learning participants, skills development, professional training, and the growth and accessibility of e-learning technologies that meet the needs of a diverse range of learners. These advancements support the e-learning market's tremendous growth; where the e-learning market size is expected to grow from USD 399.3 billion in 2022 at 14% CAGR between 2023 and 2032 [12, 13, 14].

Meanwhile, researchers [15, 16, 17] show that evaluating the interaction between e-learning dimensions that influence e-learning effectiveness has not been widely tested and developed, as well as the learners' criteria required for e-learning success evaluation is not well understood. Moreover, Romi [18] shows that most e-learning models and approaches try to find the optimal match among the e-learning components to enhance e-learning and learner performance. Romi [19] adds that most of these approaches seek instruments for measuring e-learning achievement. Therefore, e-learning dimensions' measures specifically learners' performance- remain fuzzy and elusive.

The main purpose of this research paper is to provide further insight into digital skills and their impact on e-learning system students' performance. To pursue this purpose; an investigation will be conducted on prior research to find digital skills and students' performance dimensions, a research model will be proposed that incorporates the digital skills and their impact on students' performance, and an investigation of university students will be conducted to collect the required data for testing the research model.

2. Background and Literature Review

2.1. Students Performance Concept and Measurement

Performance refers to the result of doing some actions to satisfy certain goals. Where, these goals include improving the ability to manage the physical demands of a specified work [17, 19, 20,21]. Hence, a students' performance refers to the outcomes of a students' activities in knowledge acquisition, skills development, and competencies gained through the educational process. The outcomes can be determined by academic achievement, skills development, learning progress, engagement and participation, behavioral aspects, and social and emotional learning [22].

It's highlighted that using an e-learning system enables students to acquire and transfer knowledge, enhance communication among learners, conduct open discussions, get an equal standing, around-the-clock response with no restrictions, updated content, and group collaborative learning [17, 18, 23, 24].

Al-Rahmi and Othman [25] used a set of items to measure students' academic performance; These items include academic facilitating activities, coordinating with peers, coordinating with teachers, arranging group discussions with classmates, building a student-lecturer relationship, and interacting with classmates and lecturers. Meanwhile, Dziuban et al [26] measure students' performance in online learning using engagement, opportunities to reflect on what has been learned, understanding course requirements, understanding course material, collaborating with other students, accessing and using information, more likely to ask questions, more likely to get a degree, managing learning better, motivation to success, time management skills, accurate assessment of academic progress, monitoring academic progress, and quicker response time.

Romi [17, 19] reported that prior research [20, 24, 27, 28] indicate learner performance can be measured using a set of items. Mainly, error reduction, quality improvement, reduced time required to complete the task, students' satisfaction, acceptance, freedom, adherence, attendance, enhanced communication, conducting open discussions, equal standing, around-clock responses, motivation,

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involvement, easier content, faster modification to content, and collaborative learning. Romi [18] adds that the ISO 9241 standard determines interaction goals with effectiveness, efficiency, and satisfaction; where effectiveness refers to the accuracy and completeness with which specified users can achieve specified goals in particular environments, efficiency refers to achieving goals with minimal resources, satisfaction is referred to the acceptance and comfort by users of the system. Furthermore, Abou Naaj et al [29] reported from the literature [30, 31, 32, 33, 34, 35, 36] the attributes of students' performance; which are course grades, grade point average, semester or final results of a student, as well as knowledge score and the graduate or dropout status of a student.

Therefore, measuring student performance can be aggregated from the literature as achieving student interaction goals to complete academic activities, mainly effectiveness, efficiency, and satisfaction; where effectiveness refers to the accuracy and completeness of the activities in an online course, efficiency refers to achieving academic activities with minimal resources, students' satisfaction refers to the comfort and acceptance of online learning.

2.2. Digital Skills Concept and Measurement

In their review, Ozsoy et al [37] highlight digital skills as the technical and cognitive ability to find the required information effectively and efficiently from web sources. Meanwhile, Isoda et al [38] reported from the literature [39, 40] that digital competencies are universal and must be acquired by citizens which incorporates the safe, critical, and creative use of ICTs to perform work, employment, learning, leisure, and participation in society. Furthermore, Alonso-García et al [30] reported from prior research that digital skills can be referred to as the level of information and communication technology (ICT) knowledge and skills possessed by an individual; including informational, technological, multimedia, and communication knowledge and skills.

Romi [7] reported from the literature [6, 11, 41, 42] that digital skills refer to the required knowledge and skills for individuals to use effectively ICTs for personal and professional life objectives; those skills are dynamic, and include digital information processing, communication, critical thinking, working on shared documents online, problem-solving, transferring knowledge to new working conditions, and using software and operating digital devices.

Furthermore, Romi [7] proposed a measurement tool for digital skills which was aggregated from prior research [6, 9, 11,41, 42, 43, 44, 45; 46]. This tool will be adapted to educational digital skills to measure the university students' digital skills. The tool incorporates three dimensions; common digital skills, educational digital skills, and advanced/specialized digital skills. Common digital skills are Referred to as the digital skills everyone can possess regardless of specialization, which are required for handling day-to-day life tasks; this dimension can be measured using 30 items proposed for this purpose. Educational digital skills are referred to as digital skills for handling educational tasks and events; this dimension can be measured using 19 items besides the common digital skills. Advanced/specialized digital skills are skills processed by computing/ information specialists; this dimension can be measured using 17 items proposed for this purpose, besides the common digital skills and the educational digital skills.

3. Theoretical Framework

3.1. Hypothesis Development

This study will use the predefined constructs of digital skills developed by Romi [7] as independent variables: common digital skills, educational digital skills, and advanced/specialized digital skills. As well as, the students' academic performance as a dependent variable related to completing academic activities; effectiveness, efficiency, and satisfaction.

Researchers [47, 48] discussed the relationship between digital skills and students' performance and provided a general description of this relationship. Bergdahl and Fors [47] find that engagement in technology-enhanced learning is related to students' level of digital skills, where; students with high levels of digital skills engage more in technology-enhanced learning

than students with low levels. Furthermore, Ibrahim and Aldawsari [48] found that digital capabilities positively affect nursing students' academic performance; thus, educational institutions must equip students with suitable technological infrastructures and digital resources to connect their learning with digital learning environments, resulting in good digital education, as well as, developing a strategy to improve students' digital capabilities and self-efficacy.

These results imply that; there is a relationship between digital skills and students' performance; accordingly, the general hypothesis is proposed.

General Hypothesis: digital skills positively impact students' academic performance.

Researchers [49, 50, 51, 52,53] provide further details and discussion on the relationship between digital skills components and students' performance. Ben Youssef et al [49] find that; there is a positive and significant effect on student performance at higher levels of digital skills; where, the marginal effects indicate that if advanced information and communication technology skills increase, the probability of student achievement will increase. Chaw and Tang [50] find that; problem-solving is relatively more important than communication and collaboration, digital content creation, information and data literacy, and safety for improving student learning performance. Furthermore, respondents reported above-average learning performance levels in information and data literacy, meanwhile, they consider communication and collaboration, digital content creation, and safety below-average importance for their learning performance.

Furthermore, Kure et al [51] analyze the basic and advanced digital skills across four digital subskills; search and process, produce, communicate, and digital responsibility; The main findings show that students demonstrated basic digital skills for searching and process, producing, and communicating, conversely, students seldom used advanced digital skills when they did, these involved three subskills: search, process, produce, and digital responsibility. Patrobas et al [52] find that; students' digital skills such as basic computer, internet, technical, and collaborative skills influence the teaching and learning process, in addition, the digital infrastructure, availability of the internet, professional development, electricity, technical support, readiness, awareness, overcrowded classrooms, and socio-economic conditions are factors central to the effective use of digital skills.

Moreover, Itu and Amer [53] find that the integration of digital skills into holistic education enriches the learning process by adding critical and interactive dimensions; where students can acquire technical knowledge and digital intelligence that includes an understanding of cybersecurity, ethics in the use of technology, and critical thinking in searching for information, in addition, digital skills help students adapt to the changing professional environment and enhance their active participation in a knowledge-based society.

This discussion implies that digital skills and student performance can be subdivided into further components; as used by Romi [7]. Thus, testing the general hypothesis requires subdividing the main variables into further constructs, and re-formulating the general hypothesis into three main hypotheses mainly; H1, H2, and H3.

H_1: Common digital skills affect students' academic performance.

H_2: Educational digital skills affect students' academic performance.

H_3: Advanced/Specialized digital skills affect students' academic performance.

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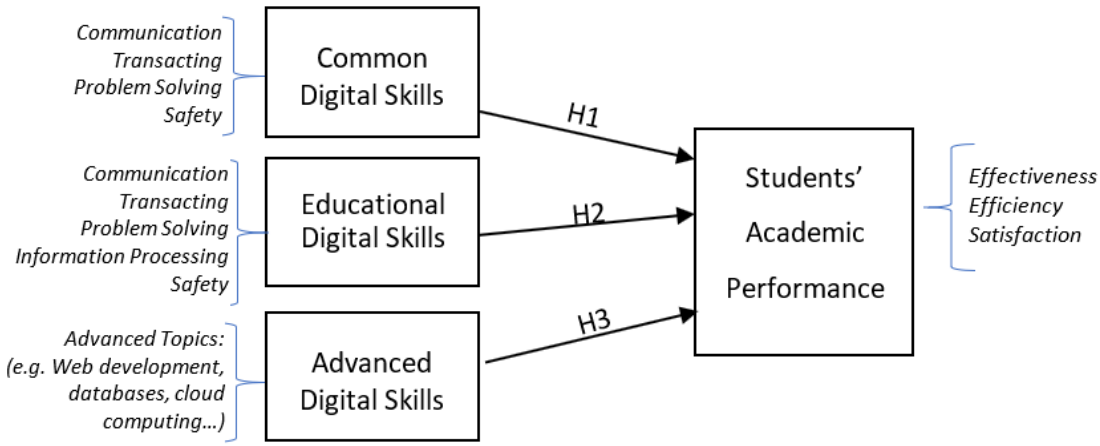

Figure 1.
The research model.

3.2. Research Model

The research model (Figure 1) incorporates digital skills constructs as independent variables and students' academic performance constructs as dependent variables. The model reflects the general hypothesis and suggests that digital skills affect students' academic performance. The model includes four constructs; three constructs of digital skills; common digital skills, educational digital skills, and advanced educational skills, in addition to the students' academic performance which includes three constructs; academic effectiveness, efficiency, and satisfaction.

4. Research Methodology and Methods

4.1. Data Collection

The main purpose of this research is to find out the impact of digital skills on students' academic performance who uses e-learning systems. For this purpose, data is collected from a sample of university students using an online questionnaire proposed for this purpose.

4.2. Sampling

The study population consists of international university students; where a lot of online questionnaires were distributed among those students via e-mails, websites, messengers, and so forth. 176 usable questionnaires were returned and used in data analysis.

4.3. Characteristics of Survey Respondents

Table 1 shows that; there is a logical distribution of respondent students from international universities. Where 34.1% are males, 65.9% are females. In addition, students' degrees were 9.6% are PhD students, 10.8 % are master's students, 70.5 are bachelor's degree students, and 9.1% are diploma degree students. Moreover; the students' degrees are distributed among all academic levels.

The majority of respondents (56.8%) show that their curricula enhance digital skills. In addition, 92.6% of the respondents access the internet daily. Meanwhile, the respondents' e-learning experiences were excellent (33.5%), good (46.6%), and reasonable (14.2%).

These results imply that the respondents possess sufficient digital skills and e-learning experiences; hence, the respondents' characteristics are suitable for testing the research hypotheses and model.

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Table 1.
Respondents' characteristics.

Demographic	Values	Frequency	Percentage
Gender	Male	60	34.1
	Female	116	65.9
Specialization	Information system-related	67	38.1
	Other majors	109	61.9
Degree	PhD	17	9.6
	Master	19	10.8
	Bachelor	124	70.5
	Diploma	16	9.1
Students' academic level	1st Year	25	14.2
	2nd Year	49	27.8
	3rd Year	38	21.6
	4th Year	41	23.3
	5th Year	23	13.1
Curricula-digital skills courses	None	34	19.3
	Don't know	42	23.9
	1-3 courses	75	42.6
	> 3 courses	25	14.2
Internet access	Daily	163	92.6
	Weekly	7	4.0
	Monthly	4	3.4
E-learning experience	Excellent	59	33.5
	Good	82	46.6
	Reasonable	25	14.2
	Weak	8	4.6
	Novice	2	1.1

4.4. Constructs Measurement

The research model incorporates digital skills constructs (common, educational, and advanced digital skills) as independent variables and student performance constructs (academic effectiveness, efficiency, and satisfaction) as dependent variables. These variables were measured using an online questionnaire which is adapted from the literature for this reason; where the responses were ranged using a Likert five-point scale using suitable ranges for each variable (construct).

4.5. Reliability and Validity of Constructs Measurement

A questionnaire was used to collect respondents' data, which is designed to measure the digital skills and students' academic performance. To ensure the reliability of the constructs' measurement tools; a reliability analysis was conducted on the collected data. The used criteria for determining the adequacy, and the reliability coefficient obtained for each construct is the one given by Cristman and Van Aelst [54]; this criterion considers alpha reliability of 0.6 or more to be an adequate reliability coefficient. In addition, factor analysis was conducted on the collected data to

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ensure the validity of the constructs' measurement tools; where, a loading factor greater than 0.5 or greater is considered as very significant [55].

Table 2 shows the internal consistency reliability and the factor analysis for the construct's measurement tools. The results show that the constructs' items are significantly correlated with the total items, and alpha reliability will not improve if any of the items are deleted. In addition, the results show that all constructs' items fall under one dimension for each construct, with a loading that exceeds 0.6. Therefore, the measures were able to demonstrate a level of construct validity.

Table 2.
Experimental scales for the used measures.

Constructs	# of items	Alpha reliability estimate	Minimum items loading	Components extracted
Common digital skills	30	0.984	0.715	1
Educational digital skills	19	0.978	0.815	1
Advanced digital skill	17	0.956	0.674	1
Students' academic effectiveness	11	0.943	0.665	1
Students' academic efficiency	6	0.904	0.699	1
Students' academic satisfaction	13	0.933	0.693	1

5. Analysis and Results

5.1. Descriptive Statistics

Table 3 shows the descriptive statistics for digital skills and students' academic performance constructs; using mean and standard deviation.

The results show that the respondents possess a satisfying common digital skill with a mean of 3.3943; where they score the highest mean (3.67) for communicating activities, followed by problem-solving activities (3.4), transacting activities (3.29), and being safe and legal online (3.26). These results imply that the respondents can perform the general digital skills activities on their own with confidence.

Furthermore, the response for the educational digital skills mean is (3.15); whereas communicating skills mean is (3.23), transacting (3.11), Problem-solving (3.23), information and data processing (2.74), and being safe and legal online (3.26). Those close means indicate that the respondents possess a satisfying digital educational skill to perform educational activities with confidence.

On the other hand, the respondents have a less advanced digital skill with a mean of (2.05); where, the results show that the respondents possess satisfying advanced digital skills in some aspects, mainly (web development, database management and programming, data analytics, operating systems, artificial intelligence, cloud-based tools, and internet of things). This result implies that the respondents – especially the specialized ones – possess some aspects of advanced digital skills.

Concerning the students' academic performance, the results show that the students' academic effectiveness with a mean of (2.71), and efficiency with a mean of (2.74) meet expectations, meanwhile, students' academic satisfaction with a mean of (2.48); which means that they are satisfied from the online learning.

Table 3.
Descriptive statistics.

Constructs		Minimum	Maximum	Mean	Std. deviation
Common digital skills	Communicating	1	5	3.67	1.173
	Transacting	1	5	3.29	1.212
	Problem solving	1	5	3.40	1.141
	Being safe and legal online	1	5	3.26	1.153
	Overall	1	5	3.39	0.94072
Educational digital skills	Communicating	1	5	3.23	1.131
	Transacting	1	5	3.11	1.252
	Problem solving	1	5	3.23	1.204
	Information and data processing	1	5	2.74	1.252
	Being safe and legal online	1	5	3.26	1.153
	Overall			3.15	0.96273
Advanced digital skills	Advanced digital skills	1	5	2.05	1.059
Students' academic performance	Effectiveness	1	5	2.71	1.118
	Efficiency	1	5	2.74	1.080
	Satisfaction	1	5	2.48	1.051

5.2. Hypothesis Testing

This study aims to find the impact of digital skills on e-learning system students' performance. Therefore, a set of hypotheses and a research model were proposed. The model incorporates three digital skills constructs (common, educational, and advanced digital skills), and three students' academic performance constructs (effectiveness, efficiency, and satisfaction).

5.3. The Impact of Common Digital Skills on Students' Academic Performance

Hypothesis H1 suggests that common digital skills impact students' academic performance. Meanwhile, common digital skills are composed of four major constructs (digital communication, digital transaction, digital problem-solving, and being safe and legal online skills). In addition, students' academic performance can be tested using three major constructs (effectiveness, efficiency, and satisfaction). Therefore, testing hypothesis H1 can be done through testing all its components.

The results of the regression analysis Table 4 show that common digital skills construct positively impact students' academic effectiveness. Where digital communication skills and digital transacting skills positively impact students' academic effectiveness; this result is statistically significant ($P < 0.05$), meanwhile the results are not significant ($P > 0.05$) for problem-solving, and being safe online.

The same results show that common digital skills construct positively impact students' academic efficiency. Where the impact of communication skills is significant ($P < 0.05$), meanwhile the results are not significant ($P > 0.05$) for transacting skills, problem-solving, and being safe online.

Furthermore, the results of regression analysis show that common digital skills construct positively impacts students' academic satisfaction. Where, the impact of digital communication skills, and digital transacting skills are significant ($P < 0.05$), meanwhile the results are not significant ($P > 0.05$) for digital problem-solving, and being safe online.

Therefore, hypothesis H1 is partially accepted; where, common digital skills - specifically, digital communication skills and digital transacting are significant ($P<0.05$) - positively impact

students' academic performance.

5.4. The Impact of Educational Digital Skills on Students' Academic Performance

Hypothesis H2 suggests that educational digital skills impact students' academic performance. Meanwhile, educational digital skills can be tested using five major constructs (digital communication skills, digital transaction skills, digital problem-solving skills, information and data processing, and being safe and legal online). In addition, students' academic performance can be tested using three major constructs (effectiveness, efficiency, and satisfaction). Therefore, testing hypothesis H2 can be done through testing all its components.

Table 4.
Regression analysis for common digital skills impact on students' academic performance.

Independent variables/ General digital skill	R	R square	Unstandardized coefficients		Standardized coefficient	t	Sig.
			B	Std. error	Beta		
Dependent variable: Students' academic effectiveness							
(Constant)			2.613	0.270		9.666	0.000
Communication	0.218	0.047	0.385	0.149	0.435	2.577	0.011
Transacting	0.218	0.047	0.351	0.171	0.412	2.057	0.041
Problem Solving	0.218	0.047	0.024	0.205	0.026	0.115	0.908
Being safe and legal online	0.218	0.047	0.025	0.148	0.028	0.172	0.864
Dependent variable: Students' academic efficiency							
(Constant)	0.188	0.035	2.434	0.261		9.318	0.000
Communication	0.188	0.035	0.327	0.149	0.379	2.202	0.029
Transacting	0.188	0.035	0.329	0.178	0.386	1.842	0.067
Problem solving	0.188	0.035	0.031	0.217	0.034	0.145	0.885
Being safe and legal online	0.188	0.035	0.028	0.151	0.031	0.187	0.852
Dependent Variable: Students' Academic satisfaction							
(Constant)	0.233	0.055	2.315	0.225		10.294	0.000
Communication			0.377	0.127	0.498	2.963	0.003
Transacting			0.292	0.146	0.393	2.000	0.047
Problem Solving			0.030	0.178	0.038	0.171	0.864
Being safe and legal online			0.054	0.128	0.068	0.420	0.675

The results of the regression analysis Table 5 show that educational digital skills construct positively impact students' academic effectiveness. Meanwhile, the results are not significant ($P > 0.05$) for all constructs. The same results show that educational digital skills construct positively impact students' academic efficiency. Where, the impact of digital problem-solving skills, and being safe and legal online skills are significant ($P < 0.05$), meanwhile the results are not significant ($P > 0.05$) for transacting skills, problem-solving skills, and Information processing skills.

Furthermore, the results of regression analysis show that educational digital skills construct positively impacts students' academic satisfaction. Where the impact of Information and data processing skills is significant ($P < 0.05$), meanwhile the results are not significant ($P > 0.05$) for digital communication skills, digital transacting skills, digital problem-solving skills, and being safe and legal online skills.

Therefore, hypothesis H2 is partially accepted; where, educational digital skills - specifically,

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digital problem-solving skills, safe and legal online skills, and information and data processing skills are significant (P<0.05) and positively impact students' academic performance.

Table 5.
Regression analysis for educational digital skills impact on students' academic performance.

Independent variables/ Educational digital skill	R	R square	Unstandardized coefficients		Standardized coefficient	t	Sig.
			B	Std. error	Beta		
Dependent variable: Students' academic effectiveness							
(Constant)	0.176	0.031	2.863	0.246		11.626	0.000
Communication			0.018	0.128	0.021	0.138	0.890
Transacting			0.138	0.101	0.187	1.368	0.173
Problem Solving			0.203	0.135	0.251	1.502	0.135
Information and data processing			0.097	0.100	0.129	0.969	0.334
Being safe and legal online			0.018	0.128	0.021	0.138	0.890
Dependent variable: Students' academic efficiency							
(Constant)	0.242	0.059	2.651	0.239		11.113	0.000
Communication			0.010	0.128	0.012	0.079	0.937
Transacting			0.116	0.099	0.155	1.168	0.245
Problem solving			0.312	0.136	0.383	2.301	0.023
Information and data processing			0.132	0.100	0.173	1.327	0.186
Being safe and legal online			0.331	0.154	0.365	2.153	0.033
Dependent variable: Students' academic satisfaction							
(Constant)	0.191	0.036	2.543	0.209		12.170	0.000
Communication			0.014	0.110	0.018	0.125	0.901
Transacting			0.105	0.085	0.163	1.229	0.221
Problem solving			0.077	0.114	0.109	0.674	0.501
Information and data processing			0.176	0.086	0.261	2.042	0.043
Being safe and legal online			0.113	0.133	0.143	0.844	0.400

5.5. The Impact of Advanced Digital Skills on Students' Academic Performance

Hypothesis H3 suggests that Advanced digital skills positively impact students' academic performance. Meanwhile, advanced digital skills include specialized courses (e.g. web development, database management, and so forth). In addition, students' academic performance can be tested using three major constructs (effectiveness, efficiency, and satisfaction). Therefore, testing hypothesis H3 can be done through testing all its components.

The results of regression analysis Table 6 show that advanced digital skills positively impact students' academic effectiveness, and efficiency; this result is significant ($P < 0.05$).

Furthermore, the results show that advanced digital skills positively impact students' academic satisfaction; but this result is not significant ($P < 0.05$). Therefore, hypothesis H3 is partially accepted; where, advanced digital skills positively impact students' academic performance, specifically academic effectiveness, and efficiency.

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Table 6.
Regression analysis for advanced digital skills impact on students' academic performance.

Dependent variables/ Advanced digital skills	R	R square	Unstandardized coefficients		Standardized coefficient	t	Sig.
			B	Std. error	Beta		
Dependent variable: Students' academic performance							
Academic effectiveness	0.168	0.028	0.184	0.084	0.168	2.192	0.030
Academic efficiency	0.163	0.027	0.182	0.084	0.163	2.159	0.032
Academic satisfaction	0.050	0.002	0.047	0.072	0.050	0.649	0.517

6. Discussion

This study aims to find how digital skills impact student performance in e-learning systems. To peruse that; a research model was proposed, and the required data were collected from a sample of international university students. The results show that the respondents possess satisfying common and educational digital skills, meanwhile, they – especially the specialized students – have advanced digital skills in related fields. Furthermore, the majority of respondents are experienced in using e-learning systems.

The research model was developed to investigate the possible impact of digital skills on students' academic performance. The data analysis supports the hypothesized relationships between the research model's independent and dependent variables. This implies that digital skills positively impact students' academic performance. This result is consistent with Patrobas et al [52] and Itu and Amer [53].

Furthermore, the results show that the level of digital skills possessed by respondents positively impacts students' academic performance; the higher the digital skills the better the academic performance. This result is consistent with Bergdahl and Fors [47] and Ben Youssef et al [49]. Moreover, the results show that the impact of common, educational, and advanced digital skills varies across the students' academic performance constructs. This result is consistent with Kure et al [51] concerning the impact of common and educational skills, but it is inconsistent concerning the impact of advanced digital skills.

While the impact of the detailed digital skills constructs on students' academic performance was not previously investigated by researchers, the current study provides further insight into all dimensions of digital skills (common, educational, and advanced) and students' academic performance dimensions (effectiveness, Efficiency, and satisfaction).

The results of hypotheses testing (Table 7) show that some aspects of digital skills have a significant positive impact on students' academic performance; therefore, those aspects will be accepted as important factors that impact students' academic performance; common communication skills, common digital transacting skills, educational digital problem-solving, educational online safety skills, educational digital information processing skills, and advanced digital skills.

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Table 7.
Summary of testing results for the model hypotheses.

Research model hypotheses	Sig.	Result	R square
H1: Common digital skills impact students' academic performance.			
Digital communication skills impact students' academic	0.011	Accepted	0.047
Digital communication skills impact students' academic	0.029	Accepted	0.035
Digital communication skills impact students' academic	0.003	Accepted	0.055
Digital transacting skills impact students' academic	0.041	Accepted	0.047
Digital transacting skills impact students' academic	0.067	Rejected	0.035
Digital transacting skills impact students' academic	0.047	Accepted	0.055
Digital problem-solving skills impact students' academic	0.908	Rejected	0.047
Digital problem-solving skills impact students' academic	0.885	Rejected	0.035
Digital problem-solving skills impact students' academic	0.864	Rejected	0.055
Digital online safety skills impact students' academic	0.864	Rejected	0.047
Digital online safety skills impact students' academic	0.852	Rejected	0.035
Digital online safety skills impact students' academic	0.675	Rejected	0.055
H2: Educational digital skills impact students' academic performance.			
Digital communication skills impact students' academic	0.890	Rejected	0.031
Digital communication skills impact students' academic	0.937	Rejected	0.059
Digital communication skills impact students' academic	0.901	Rejected	0.036
Digital transacting skills impact students' academic	0.173	Rejected	0.031
Digital transacting skills impact students' academic	0.245	Rejected	0.059
Digital transacting skills impact students' academic	0.221	Rejected	0.036
Digital problem-solving skills impact students' academic	0.135	Rejected	0.031
Digital problem-solving skills impact students' academic	0.023	Accepted	0.059
Digital problem-solving skills impact students' academic	0.501	Rejected	0.036
Digital information processing skills impact students'	0.334	Rejected	0.031
D Digital information processing skills impact students'	0.186	Rejected	0.059
Digital information processing skills impact students'	0.043	Accepted	0.036
Digital online safety skills impact students' academic	0.890	Rejected	0.031
Digital online safety skills impact students' academic	0.033	Accepted	0.059
Digital online safety skills impact students' academic	0.400	Rejected	0.036
H3: Advanced digital skills impact students' academic performance.			
Advanced digital skills impact students' academic	0.030	Accepted	0.028
Advanced digital skills impact students' academic efficiency.	0.032	Accepted	0.027
Advanced digital skills impact students' academic	0.517	Rejected	0.002

These results can be added to the research model to produce the digital skills impact on students' academic performance model (Figure 2). The model shows that a students' academic effectiveness is determined by common digital communication skills, digital transacting skills, and advanced digital skills; those determinants explain respectively 4.7%, 4.7%, and 2.8% of the variance in students' academic effectiveness.

The model shows that a students' academic efficiency is determined by common digital communication skills, educational digital problem-solving skills, educational online safety skills, and advanced digital skills; those determinants explain respectively 3.5%, 5.9%, 5.9%, and 2.8% of

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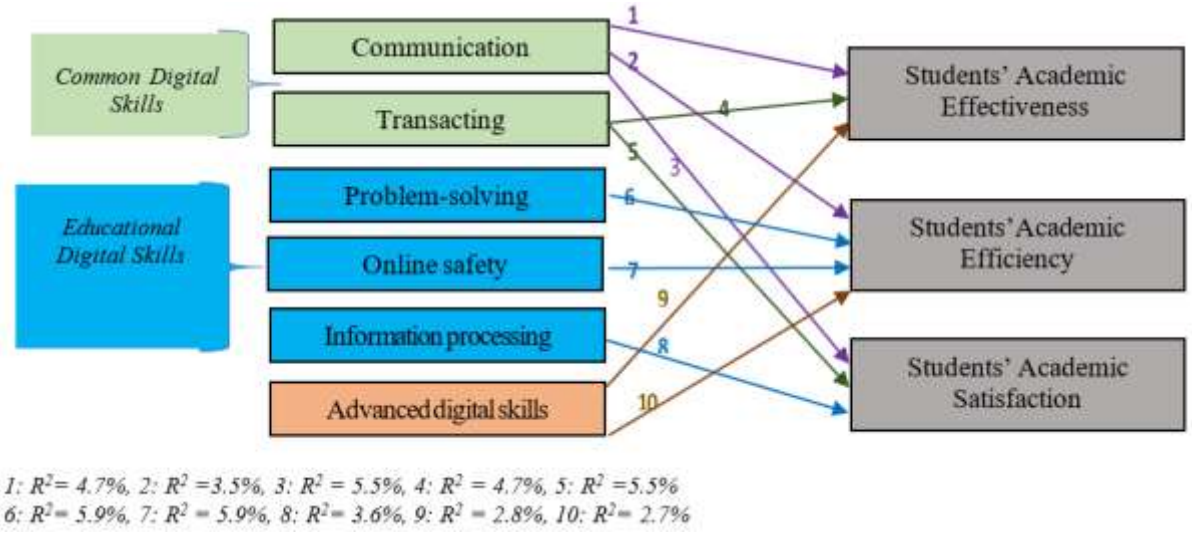
the variance in students' academic efficiency.

Moreover, the model shows that the students' academic satisfaction is determined by common digital communication skills, digital transacting skills, and educational information processing skills, those determinants explain respectively 5.5%, 4.7%, and 3.6% of the variance in students' academic satisfaction.

The model (Figure 2) implies that the highest students' academic performance can be achieved by possessing skills in the following areas:

- Common digital communicating skills: refers to the required digital skills for conducting online communication. Those skills include communicating with others digitally using email or other messaging applications (e.g. WhatsApp or Messenger), sharing documents with others by attaching them to an email, setting up an email account, communicating with others using video tools (e.g. Zoom. Meet….), using word processing applications to create documents (e.g. a CV or a letter), and posting content on social media platforms (e.g. Facebook, Instagram or Snapchat).
- Common digital transacting skills: refer to digital skills required to perform interactions with online applications. Those skills include setting up an account online that enables students to enroll in an online class (Google Classroom, zoom, etc.), using credit/debit cards or other forms of online payment to buy services online, accessing and using public services online, including filling in forms (e.g. course registration, booking appointments, student reports...), uploading documents and photographs when this is required to complete an online course, and managing transactions online securely, via websites or Apps.



1: R^2= 4.7%, 2: R^2 =3.5%, 3: R^2 = 5.5%, 4: R^2 = 4.7%, 5: R^2 =5.5%
6: R^2= 5.9%, 7: R^2 = 5.9%, 8: R^2= 3.6%, 9: R^2 = 2.8%, 10: R^2= 2.7%

Figure 2.
The digital skills impact on students' academic performance model.

Educational problem-solving skills: refer to digital skills required to solve educational problems (e.g. cases, assignments, etc.). Those skills include using the Internet to find information that helps in solving problems, cases, and home works, using different digital tools to improve performance i.e. saving time or more efficient performance, and using appropriate software to manipulate different tasks (e.g. Spreadsheets, MS Project, special online software…).

Being safe and legal online: the required digital skills for safety and legal actions online. Those skills include responding to requests for authentication (e.g. reactivating an account when I've forgotten my password), recognizing and avoiding suspicious links in email, websites, social media messages, knowing that clicking on these links is a risk, carefulness with what is being shared online, keeping the information which is used to access online accounts secure by using different and secure passwords for

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websites and accounts, making sure not to share or use the other's data or intellectual property without their consent, assessing the risks and threats involved in carrying out activities online and act accordingly, identifying secure websites by looking for the padlock and 'https' in the address bar, setting privacy settings on social media and other accounts, updating computer security systems when necessary to prevent viruses and other risks.

- Digital information and data processing: refers to the required digital skills for handling online content. Those skills include accessing, synchronizing, and sharing information across different devices (e.g. managing a calendar or appointment system via phone or desktop), developing digital content, and integrating and re-elaborating digital content.
- Advanced digital skills: refer to the required digital skills for handling applications and advanced online aspects; mainly, basics of applications development, augmented reality, and database management systems.

7. Conclusion and Recommendations

This research paper aims to determine the impact of digital skills on students' academic performance in e-learning systems. A comprehensive model was developed; which incorporates the dimensions of students' academic performance as dependent variables, and digital skills dimensions as independent variables. Data were collected from university students to examine the developed model.

The results show that the respondents possess satisfying common and educational digital skills. Meanwhile, they have less advanced digital skills. On the other hand, the respondents' academic effectiveness and efficiency meet expectations, meanwhile, their satisfaction is moderate. Furthermore, the findings show that the regression analysis supports the hypothesized relationships between independent and dependent variables in the research model; where digital skills dimensions positively impact students' academic performance dimensions.

The research provides further insight into the impact of digital skills dimensions on students' academic performance; it integrates the results with prior research and provides a suggested model (Figure 2) that explains the variance of students 'academic performance dimensions depending on digital skills.

The model variance explanations were; common digital communication skills, digital transacting skills, and advanced digital skills respectively 4.7%, 4.7%, and 2.8% of the variance in students' academic effectiveness. As well as, common digital communication skills, educational digital problem-solving skills, educational online safety skills, and advanced digital skills explain respectively 3.5%, 5.9%, 5.9%, and 2.8% of the variance in students' academic efficiency. Moreover, common digital communication skills, digital transacting skills, and educational information processing skills explain respectively 5.5%, 4.7%, and 3.6% of the variance in students' academic satisfaction.

The results indicate that achieving the highest student academic performance requires a combination of digital skills dimensions to be possessed by those students; mainly common digital communicating and transacting skills, educational digital problem-solving skills, digital safety skills, educational information and data processing skills, and some aspects of advanced digital skills such as basics of applications development, augmented reality, and database management systems.

While the digital skills dimensions explain the variance in students' academic performance, it is recommended to further quest for more independent variables that may impact the student's academic performance dimensions.

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References

[1] IMARC Group, 2023. Soft Skills Training Market Report. *Last Accessed From*: https://www.imarcgroup.com/soft-skills-training-market
[2] Law, M., 2023. Digital skills drive gains for organisations and economy. *Last Accessed From:* https://technologymagazine.com/articles/digital-skills-drive-gains-for-organisations-and-economy.
[3] Statista, 2023. Digital transformation - statistics & facts. *Last Accessed From:* https://www.statista.com/topics/6778/digital-transformation/#topicOverview
[4] Lingga, I. S., 2020. Analyzing the importance of user competency to the effectiveness of accounting information system in banking sector. *In 3rd Asia Pacific Management Research Conference (APMRC 2019)* (pp. 117-122). Atlantis Press.
[5] Oberländer, M., Beinicke, A., & Bipp, T., 2020. Digital competencies: A review of the literature and applications in the workplace. *Computers & Education*, 146, 103752.
[6] Mazurchenko, A., Zelenka, M., & Maršíková, K., 2022. DEMAND FOR EMPLOYEES'DIGITAL SKILLS IN THE CONTEXT OF BANKING 4.0. *E&M Ekonomie a Management*, 25(2), 41-58.
[7] Romi I.M., 2024. Digital Skills Measures for Digitalization - An Aggregative Analysis. *Pakistan Journal of Life and Social Sciences (PJLSS)*. 22(1): 960-971. Doi: https://doi.org/10.57239/PJLSS-2024-22.1.0067
[8] Fitriani, H. and Ajayi, S., 2021. Preparing Indonesian civil engineering graduates for the world of work, *Industry and Higher Education*, 36 (4), 471–487.
[9] Siddiqui, F. H., Abdekhodaee, A., & Thaheem, M. J., 2022. Taxonomy of Digital Skills Needed in the Construction Industry: A Literature Review. *In Proceedings of the 45th AUBEA Conference*, Sydney, Australia (pp. 23-25).
[10] Broadband Commission for Sustainable Development, 2017. Working Group on Education: Digital skills for life and work. Broadband Commission for Sustainable Development. *Last accessed from* https://unesdoc.unesco.org/ark:/48223/pf0000259013
[11] Lang, G., & Triantoro, T., 2022. Upskilling and Reskilling for the Future of Work: A Typology of Digital Skills Initiatives. *Information Systems Education Journal*, 20(4), 97-106.
[12] Machinery Professional Community, 2023. Academic E-Learning Market Size In 2023: Share, Latest Trends &Forecast 2023 To 2030. *Last Accessed From:* https://www.linkedin.com/pulse/academic-e-learning-market-size-2023/
[13] Global Market Insight, 2023. E-learning Market Size. *Last Accessed From:* https://www.gminsights.com/industry-analysis/elearning-market-size
[14] Verified Market Reports, 2023. Global E-Learning Market Size, ShareProjections for 2023-2030. *Last Accessed From:* https://www.verifiedmarketreports.com/
[15] Hoffman, J., 2005. *How to Design for the Live Online Classroom: Creating great interactive and collaborative training using Web conferencing*. Brandon Hall, Sunnyvale.
[16] Sridharan, B., Deng, H., Kirk, J., Corbitt, B., 2010, Structural Equation Modeling for Evaluating the User Perceptions of e-Learning Effectiveness in Higher Education, *18th European Conference on Information Systems*.
[17] Romi, I. M., 2017. A model for e-learning systems success: Systems, determinants, and performance. *International Journal of Emerging Technologies in Learning (iJET)*, 12(10).
[18] Romi, I. M., 2023a. E-Learning Success: Requirements, Opportunities, and Challenges. *Reimagining Education-The Role of E-Learning, Creativity, and Technology in the Post-Pandemic Era*.
[19] Romi, I.M., 2023b. An Adaptive E-Learning Systems Success Model. *International Journal of Emerging Technologies in Learning (iJET)*, 18(18), pp. 177–191. https://doi.org/10.3991/ijet.v18i18.42929
[20] Te'eni, D., Carey, J., Zhang, P., 2007. *Human Computer Interaction: Developing Effective Organizational Information Systems*, John Wiley & Sons Inc.: USA.
[21] Moustakas L, Robrade D. The challenges and realities of e-learning during COVID-19: The case of university sport and physical education. *Challenges*. 2022;13(1),9.
[22] OpenAI. (2024). ChatGPT [Large language model]. https://chat.openai.com
[23] Piskurich, G. M., 2006. Online learning, E-Learning fast, cheap, and good Performance Improvement, *ProQuest Education Journals*, 45(1), 18-25.
[24] Kumar, K. R., Ravi, S., Srivatsa, S.K., 2011, Role of a Teacher in e-learning & Face-to-Face Learning Environment, *International Journal of Computer Science and Network Security*, 11(7): pp. 72-80.
[25] Al-Rahmi, W., & Othman, M., 2013. The impact of social media use on academic performance among university students: A pilot study. *Journal of information systems research and innovation*, 4(12), 1-10.
[26] Dziuban, C., Moskal, P., Thompson, J., Kramer, L., DeCantis, G., & Hermsdorfer, A., 2015. Student Satisfaction with

Online Learning: Is It a Psychological Contract?. *Online Learning*, 19(2), n2.
[27] Maloney, S., Haas, R., Keating, J.L., Molloy, E., Jolly, B., Sims, J., Morgan, P. and Haines, T., 2011. Effectiveness of Web-based versus face-to-face delivery of education in prescription of falls-prevention exercise to health professionals: randomized trial. *Journal of medical Internet research*, *13*(4), p.e1680.
[28] Noesgaard, S. S., & Ørngreen, R., 2015. The effectiveness of e-learning: An explorative and integrative review of the definitions, methodologies and factors that promote e-Learning effectiveness. *Electronic Journal of E-Learning*, 13(4), 278-290.
[29] Abou Naaj, M., Mehdi, R., Mohamed, E. A., & Nachouki, M., 2023. Analysis of the factors affecting student performance using a neuro-fuzzy approach. *Education Sciences*, 13(3), 313.
[30] Alonso-García, S., Victoria-Maldonado, J. J., García-Sempere, P. J., & Lara-Lara, F., 2023. Student evaluation of teacher digitals skills at Granada University. *In Frontiers in Education* (Vol. 7, p. 1069245). Frontiers Media SA.
[31] Kemper, L., Vorhoff, G., & Wigger, B. U., 2020. Predicting student dropout: A machine learning approach. *European Journal of Higher Education*, 10(1), 28-47.
[32] Nabil, A., Seyam, M., & Abou-Elfetouh, A., 2021. Prediction of students' academic performance based on courses' grades using deep neural networks. *IEEE Access*, 9, 140731-140746.
[33] Zeineddine, H., Braendle, U., & Farah, A., 2021. Enhancing prediction of student success: Automated machine learning approach. *Computers & Electrical Engineering*, 89, 106903.
[34] Nachouki, M., & Abou Naaj, M., 2022. Predicting student performance to improve academic advising using the random forest algorithm. *International Journal of Distance Education Technologies* (IJDET), 20(1), 1-17.
[35] Poudyal, S., Mohammadi-Aragh, M. J., & Ball, J. E., 2022. Prediction of student academic performance using a hybrid 2D CNN model. *Electronics*, 11(7), 1005.
[36] Mehdi, R., Nachouki, M., 2023. A neuro-fuzzy model for predicting and analyzing student graduation performance in computing programs. *Education and Information Technologies*, 28(3), 2455-2484.
[37] Ozsoy, D., Akbulut, E., Atılgan, S. S., & Muschert, G. W., 2020. Determinants of digital skills in Northeast Anatolia, Turkey. Journal of multicultural discourses, 15(2), 148-164.
[38] Isoda, M., Estrella, S., Zakaryan, D., Baldin, Y., Olfos, R., & Araya, R., 2021. Digital competence of a teacher involved in the implementation of a cross-border lesson for classrooms in Brazil and Chile. *International Journal for Lesson & Learning Studies*, 10(4), 362-377.
[39] Saavedra, A.R. and Opfer, V.D., 2012, Learning 21st-century skills requires 21st-century teaching, *Phi Delta Kappan*, 94(2), pp. 8-13, doi: 10.1177/003172171209400203.
[40] Ferrari, A., 2012. Digital Competence in Practice, European Commission Joint Research Centre. Institute for Prospective Technological Studies, *Seville*, doi: 10.2791/82116.
[41] ITU, 2020. Digital Skills Assessment Guidebook. ITU Publications. *Last accessed from* https://academy.itu.int.
[42] AWS, 2022. AWS Global Digital Skills Study: The Economic Benefits of Tech-Savvy Workforce. *Gallup, Inc.*
[43] Desjardins, R., Thorn, W., Schleicher, A., Quintini, G., Pellizzari, M., Kis, V., & Chung, J. E., 2013. OECD skills outlook 2013: First results from the survey of adult skills. *Journal of Applied Econometrics*, 30(7), 1144-1168.
[44] Bank, Lloyds., 2021. Essential Digital Skills Report, 2021. *Last accessed from* https://charnwood.moderngov.co.uk/
[45] Bouchrika, I., 2023. Information Systems Careers: 2024 Guide to Career Paths, Options & Salary. *Last accessed from:* https://research.com/careers/information-systems-careers.
[46] Europass, 2023. Test Your Digital Skills. *Last accessed from:* https://europa.eu/europass/digitalskills/screen/home.
[47] Bergdahl, N., Nouri, J., & Fors, U., 2020. Disengagement, engagement and digital skills in technology-enhanced learning. *Education and information technologies*, 25(2), 957-983.
[48] Ibrahim, R. K., Aldawsari, A. N., 2023. Relationship between digital capabilities and academic performance: the mediating effect of self-efficacy. *BMC nursing*, 22(1), 434.
[49] Ben Youssef, A., Dahmani, M., & Ragni, L., 2022. ICT use, digital skills and students' academic performance: Exploring the digital divide. *Information*, 13(3), 129.
[50] Chaw, L. Y., Tang, C. M., 2022. The relative importance of digital competences for predicting student learning performance: an importance-performance map analysis. *In 21st European Conference on e-Learning ECEL 2022* (p. 61).
[51] Kure, A. E., Brevik, L. M., & Blikstad-Balas, M., 2023. Digital skills critical for education: Video analysis of students' technology use in Norwegian secondary English classrooms. *Journal of computer assisted learning*, 39(1), 269-285.
[52] Patrobas, M., Machumu, H.J. and Mtawa, N., 2023. Digital skills and learning in Tanzania secondary schools: Students and teachers' influence. *Qeios*.
[53] Itu, Y., Amer, M. A. B., 2024. Designing the Future: Digital Skills and Intelligence in Holistic Education. *International Journal of Social and Education*, 1(3), 608-620.
[54] Cristman, A., Van Aelst, S., 2006. Robust estimation of Cronbach's alpha. *Journal of Multivariate Analysis*, 97(7): pp. 1660-1674.
[55] Hair, J. F., Anderson, R. E., Tatham, R., Black, W., 1998. *Multivariate Data Analysis, 5th Ed.* Upper Saddle River, NJ: Prentice Hall.