“Exploratory and confirmatory factor analysis of digital entrepreneur skills”

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EXPLORATORY AND CONFIRMATORY FACTOR ANALYSIS OF DIGITAL ENTREPRENEUR SKILLS

Abstract

Research in the field of entrepreneurship has become an intriguing area for further investigation. In an era where digital advancements are ubiquitous, previous researchers have identified a gap: the lack of a specific instrument to identify digital entrepreneur skills. Therefore, this study aims to determine the constructs of students' digital entrepreneur skills. The analysis techniques include confirmatory factor analysis (CFA), exploratory factor analysis (EFA), Pearson correlation, Kendall's, Spearman's, and Cronbach's alpha. The study was conducted over five phases with 235 participants from university students in Indonesia who run or own a business. The results revealed strong instrument validity with robustness ranging from significant Pearson, Kendall's, and Spearman's analyses (<0.05) and Cronbach's alpha (>0.60). The exploratory factor analysis indicated a Kaiser-Meyer-Olkin value of 0.954 (>0.05) and Bartlett's test (0.000 < 0.05), with all items having values of anti-image (>0.50), communalities (> 0.50), and factor loadings (> 0.40), uncovering three components. Lastly, the CFA demonstrated an overall good fit model, with high first-order factor loadings (>0.60) and a second-order construct digital entrepreneur skills comprising three components: interpersonal digital skills with a factor loading of 0.890, idea and technology management skills (0.920), and adaptation and innovation skills (1.020). The study highlights the critical need for students to develop digital entrepreneurial skills encompassing interpersonal digital skills, ideation, and technology management, as well as adaptation and innovation abilities to thrive in the digital economy and enhance their personal and professional growth.

Keywords confirmation, digital, entrepreneur, entrepreneurship, exploration, factor, skills, undergraduates

JEL Classification A20, L26, J24

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INTRODUCTION

Integrating technological advancements with entrepreneurial activities is becoming increasingly important in the rapidly evolving digital entrepreneurial landscape. This extends to the demand for enhanced capabilities. This relationship between digital technologies and entrepreneurship reshapes economic opportunities, driving innovation and influencing global business markets. This ultimate goal marks the urgency of further examination of this topic through a scientific approach. Digital transformation, characterized by the proliferation of digital tools and platforms, has democratized the entrepreneurial ecosystem, allowing individuals to launch and grow digital businesses more efficiently. Ease then becomes the framework of capability in preparing a generation ready for the changes in the ecosystem.

However, while digital transformation simplifies some aspects of entrepreneurship, it also demands a unique set of skills to utilize its potential fully. Higher education has been highlighted as a place to serve as an incubator for skills development. The importance of higher education institutions in this context cannot be overstated, as they play a

critical role in equipping students with the competencies required to thrive in the digital entrepreneurship ecosystem. These competencies cover a wide range of skills: computational ability, critical thinking, creativity, and basic entrepreneurial skills.

1. LITERATURE REVIEW

The field of digital entrepreneurship has become a crucial aspect, contributing to economic opportunities, innovation, and business markets (Elia et al., 2020; Hsieh & Wu, 2019; Kraus et al., 2019; Verhoef & Bijmolt, 2019; Wirtz, 2019). Hsieh and Wu (2019), Khumsamart (2022), Kuester et al. (2018), Song (2019), and Wirtz (2019) have argued that advancements in digitization have made it easier for individuals to initiate and develop digital business initiatives. For example, Anderson (2012) emphasized that digital transformation has facilitated online interactions within the industrial sector. However, despite the improved ease provided by digital transformation, digital transformation in the entrepreneurial sector still requires skills to harness its potential (Hsieh & Wu, 2019; Khumsamart, 2022; Kuester et al., 2018; Song, 2019; Wirtz, 2019). In this regard, the role of higher education institutions, such as universities and colleges, is central in equipping students with essential skills to effectively participate in the digital entrepreneurial ecosystem. These skills include specific abilities related to computation skills (Embodo & Baraquia, 2019; Mahmoud Zaki Ali & Al-Abyadh, 2022; Malizia et al., 2017; Sawiji et al., 2023) and critical thinking (Todd & Elliott, 2019; Polat & Aydın, 2020; van Laar et al., 2018). Moreover, creativity (Alt & Raichel, 2020; Capron Puozzo & Audrin, 2021; Pizzingrilli et al., 2015; Tang et al., 2020) and entrepreneurial skills (Daniel et al., 2017; Khelifi, 2023; Salamzadeh et al., 2022; Winarno, 2016) are also vital. This demonstrates that each activity requires specific skills, including digital and entrepreneurial skills.

Unfortunately, previous research has left a gap where earlier experts (Daniel et al., 2017; Gieure et al., 2019; Khelifi, 2023; Koyuncuoglu, 2021; Mojab et al., 2011; Salamzadeh et al., 2022; Winarno, 2016) have developed or analyzed entrepreneurial skills in a general sense. This created a need for more specific instruments to identify or reflect the digital entrepreneurial skills of individuals, particularly within the university context. This is of high urgency as identifying the fundamental aspects is crucial for enhancing entrepreneurial skills in the digital era. Therefore, the need for a valid instrument is paramount for further decision-making. To achieve a valid instrument, a series of validity tests are required to assess the reliability and factors formed by each statement item used.

Entrepreneurial skills are essential for individuals in the field of entrepreneurship (Gieure et al., 2019; Koyuncuoglu, 2021; Mojab et al., 2011). An entrepreneur is an individual who operates and maintains a business venture (Ratten, 2019). More specifically, these skills refer to the abilities and qualities that help individuals become more effective in running a business or entrepreneurial initiative (Meissner & Shmatko, 2019; Mojab et al., 2011). These skills are highly important in today's dynamic and competitive business world, and they can be developed under certain circumstances (Meissner & Shmatko, 2019). These skills can be reflected through teamwork skills, initiative, ambition, adaptability, flexibility, risk-taking, and a willingness to learn (Mojab et al., 2011). Unfortunately, previous instrument development in this area has left a gap in the form of entrepreneurial skills instruments that have not been adapted to the developments in the digital sector. Yet, the digital sector offers great opportunities for entrepreneurship (Elia et al., 2020; Hsieh & Wu, 2019; Kraus et al., 2019; Verhoef & Bijmolt, 2019; Wirtz, 2019). Digital entrepreneurship is an important aspect that contributes significantly to economic opportunity and innovation. However, previous research has shown a need for more development of specific instruments to measure digital entrepreneurship skills. Higher education, especially universities and colleges, equips students with the necessary skills to succeed in this field, including computational ability, critical thinking, and creativity.

This study aims to address the gap by conducting exploratory and confirmatory factor analysis to develop a valid and reliable instrument to measure digital entrepreneurship skills in university students. The hypothesis is as follows:

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H1: The newly developed instrument for measuring digital entrepreneurial skills among undergraduates is a valid and reliable tool capable of accurately assessing the specific competencies required for success in the digital entrepreneurship sector.

To achieve the set goal, the study identified three main components – interpersonal digital skills, ideation and technology management skills, and adaptation and innovation skills – essential for success in the digital entrepreneurship sector.

2. METHOD

Primary analysis techniques include exploratory factor analysis and confirmatory factor analysis, along with supporting analysis techniques such as Pearson correlation analysis, Kendall's tau_b analysis, Spearman's rho analysis, and Cronbach's alpha analysis. This is done as a robustness check to obtain statement items that can reflect a construct with high reliability. Thus, this study not only seeks to fill a gap in the existing literature but also provides a more robust methodology for validating the instrument. The focus on specific digital skills required for digital entrepreneurship is an innovative aspect of this research, differentiating it from previous, more general studies.

The sample consisted of 235 university students in Indonesia who run or own a business. It is necessary to explain how the students who manage, or own businesses were selected. This paper employs several analysis techniques, including confirmatory factor analysis, exploratory factor analysis, Pearson correlation, Kendall's tau_b, Spearman's rho, and Cronbach's alpha. These techniques are utilized as a robustness check for the instrument measuring digital entrepreneurial skills of undergraduate students to ensure a strong validity of the instrument. To clarify this process, the study follows five phases, as illustrated in Figure 1.

Phase 1 involves the development of the instrument based on the concept and theoretical standards of entrepreneurship. Phase 2 entails data collection using the instrument prepared in Phase 1. Data collection is conducted at Sebelas Maret University. Phase 3 comprises data analysis using Pearson correlation, Kendall's tau_b, and

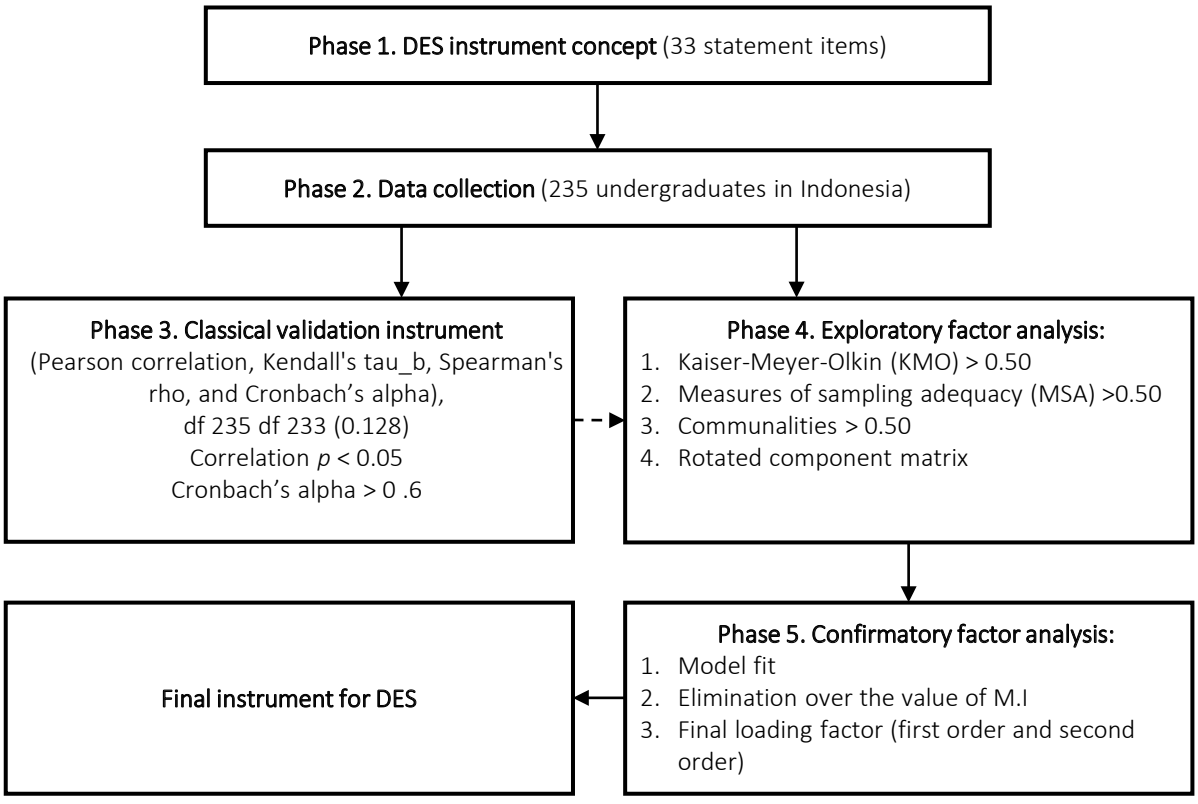

Figure 1. Research phases

Spearman's rho, with a significance level of $p < 0.05$ and a Cronbach's alpha value > 0.60. Statement items that meet the criteria in Phase 3 are then moved to Phase 4. In Phase 4, further analysis is conducted using exploratory factor analysis, with requirements such as Kaiser-Meyer-Olkin (KMO) > 0.50, measures of sampling adequacy (MSA) > 0.50, communality > 0.50, and rotated component matrix (loading factor) > 0.40. If any item fails to meet these criteria, it is eliminated, and Phase 4 analysis is repeated until the criteria are met, enabling the progression to Phase 5. Phase 5 involves data analysis using confirmatory factor analysis, with prerequisites for model fit according to good fit criteria: chi-square ($\chi 2$) $0 \leq \chi 2 \leq 2df$, chi-square relatives ($\chi 2/df$) $0 \leq \chi 2/df \leq 2$, root mean square error of approximation (RMSEA) $0 \leq RMSEA \leq 0.05$, normed fit index (NFI) $0.95 \leq NFI \leq 1.00$, comparative fit index (CFI) $0.97 \leq CFI \leq 1.00$, goodness-of-fit (GFI) $0.95 \leq GFI \leq 1.00$, and adjusted goodness-of-fit-index (AGFI) $0.90 \leq AGFI \leq 1.00$ (Schermelleh-Engel et al., 2003). If the model fit criteria are not met, item elimination is performed based on high modification indices (MI) (Thakkar, 2020).

3. RESULTS

3.1. Phase 1 – DES instrument concept

In this phase, the process of formulating statement items is carried out by adapting the findings of previous researchers, where entrepreneurial skills are recognized as crucial skills for an entrepreneur (Gieure et al., 2019; Koyuncuoglu, 2021; Mojab et al., 2011). This study adapts indicators from Mojab et al. (2011) as the basis for formulating statement items adjusted to the development of the digital sector (see Table 1).

Table 1. Draft instrument of DES

Code	Item Description
Q1	I negotiate to reach an agreement with others.
Q2	I interact with most of my friends on the internet.
Q3	I prefer working in a team to complete tasks/jobs rather than working alone.
Q4	I explore current business opportunities on the internet.
Q5	When facing a problem, I solve it systematically, starting from identifying the issue to finding a solution.
Q6	I strive to develop my creativity and innovation in fields that align with my talents and interests.
Q7	I think about ways to achieve success in the future.
Q8	I develop my skills to compete with others.
Q9	I easily adapt to new environments.
Q10	I quickly become acquainted with people I have just met.
Q11	I am open to other people's opinions.
Q12	I do not impose my will on others.
Q13	I take risks in a job/task.
Q14	I try new things that I find on the internet.
Q15	I want to learn something new.
Q16	I want to master various skills that match my talents.
Q17	I like to read books that I think can broaden my knowledge.
Q18	I write down ideas that suddenly come to my mind.
Q19	I understand current information technology.
Q20	I read books from start to finish.
Q21	I calculate all my expenses in a period (daily, weekly, monthly, annually).
Q22	I apply mathematical knowledge in daily life (such as calculating expenses and savings).
Q23	I consider all my expenses and income in a period.
Q24	I delve into the science of technology.
Q25	I spend my free time browsing the internet.
Q26	I visit websites that provide useful information for me.
Q27	I strive to interact properly with others.
Q28	I analyze the truth of every piece of information I receive.
Q29	When interacting with others, I give my conversation partner a chance to speak first.
Q30	I evaluate the achievements I have made.
Q31	I seek various sources (books or internet) to solve difficult problems.
Q32	I am careful when analyzing an event to avoid making wrong decisions.
Q33	I evaluate the ideas I present.

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3.2. Phase 2 – Data collection

Once the instrument is declared valid by experts, data collection is carried out at one of the major universities in Indonesia. Every randomly encountered student is asked for their willingness to fill out the instrument. The study assures participants that the collected data will be kept confidential, solely used for research purposes, and devoid of any conflicts of interest. Eventually, a total of 235 data points were gathered from 300 participants who took part in this study, with 65 data points excluded because participants did not complete the statement items in the instrument.

3.3. Phase 3 – Classical validation instrument

The results of the analysis in this phase indicate that all the statement items tested using Pearson correlation, Kendall's tau, and Spearman's rho analysis have $p < 0.05$. This means that all the items withstand the robustness check with these three analysis techniques. Additionally, data reliability is confirmed through Cronbach's alpha test, which yields a value of 0.970 > 0.6. Furthermore, the significant correlations (see Table 2) suggest that the tested items reflect the same construct.

3.4. Phase 4 – Exploratory factor analysis

After the previous phase demonstrated that all items were deemed valid and reliable, with no items eliminated, the EFA analysis revealed two steps (see Table 3) due to the presence of statement items that did not meet the predetermined communality prerequisites. Consequently, these items were eliminated, and a retest of EFA was conducted. In the first step, the KMO value (.954 > 0.05) and Bartlett's test (.000 < 0.05) met the requirements. Additionally, the anti-image correlation had values with MSA > 0.5. However, in this first step, some items had communalities < 0.50 (Q1, Q3, Q17, and Q25), which were eliminated in this step. As a result, in the second step, the KMO value (.955 > 0.50), Bartlett's test (.000 < 0.05), anti-image correlation with values for each item > 0.50, and communalities for all statement items > 0.50 were achieved. This indicates that the EFA model has been deemed fit, resulting in a total of 29 statement items, down from the initial 33 items (4 statement items were eliminated in step 1).

Regarding the loading factors in the EFA, in step 1, justification for the loading factors produced could not be made since the model fit was not achieved. However, in step 2, the loading factors could be justified as the model fit was achieved. As a result, three components reflecting a construct were formed, with the highest loading factor on item Q22 (0.819) and the lowest loading factor on Q19 (0.494). This lowest value aligns with the criteria outlined by Hair et al. (2010), stating that in social research, the minimum loading factor should be > 0.40. Furthermore, the first component consists of 19 statement items, the second component has six statement items, and the third component contains four statement items (see Table 4). To test the robustness of each of these items, a CFA model with first-order and second-order components was established in the subsequent phase.

Table 2. Correlation and reliability test

Pearson Correlation						Kendall's tau_b						Spearman's rho					
Item	P	Item	P	Item	P	Item	p	Item	P	Item	p	Item	p	Item	p	Item	p
Q1	0.000	Q12	0.000	Q23	0.000	Q1	0.000	Q12	0.000	Q23	0.000	Q1	0.000	Q12	0.000	Q23	0.000
Q2	0.000	Q13	0.000	Q24	0.000	Q2	0.000	Q13	0.000	Q24	0.000	Q2	0.000	Q13	0.000	Q24	0.000
Q3	0.000	Q14	0.000	Q25	0.000	Q3	0.000	Q14	0.000	Q25	0.000	Q3	0.000	Q14	0.000	Q25	0.000
Q4	0.000	Q15	0.000	Q26	0.000	Q4	0.000	Q15	0.000	Q26	0.000	Q4	0.000	Q15	0.000	Q26	0.000
Q5	0.000	Q16	0.000	Q27	0.000	Q5	0.000	Q16	0.000	Q27	0.000	Q5	0.000	Q16	0.000	Q27	0.000
Q6	0.000	Q17	0.000	Q28	0.000	Q6	0.000	Q17	0.000	Q28	0.000	Q6	0.000	Q17	0.000	Q28	0.000
Q7	0.000	Q18	0.000	Q29	0.000	Q7	0.000	Q18	0.000	Q29	0.000	Q7	0.000	Q18	0.000	Q29	0.000
Q8	0.000	Q19	0.000	Q30	0.000	Q8	0.000	Q19	0.000	Q30	0.000	Q8	0.000	Q19	0.000	Q30	0.000
Q9	0.000	Q20	0.000	Q31	0.000	Q9	0.000	Q20	0.000	Q31	0.000	Q9	0.000	Q20	0.000	Q31	0.000
Q10	0.000	Q21	0.000	Q32	0.000	Q10	0.000	Q21	0.000	Q32	0.000	Q10	0.000	Q21	0.000	Q32	0.000
Q11	0.000	Q22	0.000	Q33	0.000	Q11	0.000	Q22	0.000	Q33	0.000	Q11	0.000	Q22	0.000	Q33	0.000
Cronbach's Alpha																	
0.970																	

Table 3. KMO, anti-image correlation, and communality

Category of Analysis		Step 1						Step 2					
KMO and Bartlett's	KMO	0.954						0.955					
	Sig.	0.000						0.000					
Anti-image Correlation		**Item**	**MSA**	**Item**	**MSA**	**Item**	**MSA**	**Item**	**MSA**	**Item**	**MSA**	**Item**	**MSA**
		Q1	0.974[a]	**Q12**	0.973[a]	**Q23**	0.965[a]	**Q2**	0.977[a]	**Q13**	0.968[a]	**Q24**	0.931[a]
		Q2	0.977[a]	**Q13**	0.967[a]	**Q24**	0.941[a]	**Q4**	0.972[a]	**Q14**	0.961[a]	**Q26**	0.946[a]
		Q3	0.957[a]	**Q14**	0.963[a]	**Q25**	0.938[a]	**Q5**	0.973[a]	**Q15**	0.967[a]	**Q27**	0.954[a]
		Q4	0.973[a]	**Q15**	0.968[a]	**Q26**	0.947[a]	**Q6**	0.956[a]	**Q16**	0.967[a]	**Q28**	0.956[a]
		Q5	0.967[a]	**Q16**	0.957[a]	**Q27**	0.951[a]	**Q7**	0.943[a]	**Q18**	0.945[a]	**Q29**	0.969[a]
		Q6	0.959[a]	**Q17**	0.911[a]	**Q28**	0.947[a]	**Q8**	0.969[a]	**Q19**	0.962[a]	**Q30**	0.970[a]
		Q7	0.948[a]	**Q18**	0.951[a]	**Q29**	0.968[a]	**Q9**	0.893[a]	**Q20**	0.918[a]	**Q31**	0.969[a]
		Q8	0.970[a]	**Q19**	0.963[a]	**Q30**	0.968[a]	**Q10**	0.880[a]	**Q21**	0.926[a]	**Q32**	0.972[a]
		Q9	0.902[a]	**Q20**	0.886[a]	**Q31**	0.970[a]	**Q11**	0.970[a]	**Q22**	0.898[a]	**Q33**	0.967[a]
		Q10	0.894[a]	**Q21**	0.929[a]	**Q32**	0.972[a]	**Q12**	0.974[a]	**Q23**	0.966[a]		
		Q11	0.965[a]	**Q22**	0.900[a]	**Q33**	0.967[a]						
Communalities		**Item**	**Ext**	**Item**	**Ext**	**Item**	**Ext**	**Item**	**Ext**	**Item**	**Ext**	**Item**	**Ext**
		Q1	0.422	**Q12**	0.548	**Q23**	0.613	**Q2**	0.570	**Q13**	0.583	**Q24**	0.531
		Q2	0.577	**Q13**	0.561	**Q24**	0.543	**Q4**	0.630	**Q14**	0.640	**Q26**	0.661
		Q3	0.428	**Q14**	0.638	**Q25**	0.466	**Q5**	0.712	**Q15**	0.744	**Q27**	0.695
		Q4	0.632	**Q15**	0.743	**Q26**	0.657	**Q6**	0.738	**Q16**	0.729	**Q28**	0.639
		Q5	0.713	**Q16**	0.731	**Q27**	0.698	**Q7**	0.592	**Q18**	0.554	**Q29**	0.680
		Q6	0.730	**Q17**	0.459	**Q28**	0.626	**Q8**	0.729	**Q19**	0.578	**Q30**	0.668
		Q7	0.592	**Q18**	0.553	**Q29**	0.681	**Q9**	0.737	**Q20**	0.528	**Q31**	0.653
		Q8	0.728	**Q19**	0.578	**Q30**	0.663	**Q10**	0.764	**Q21**	0.696	**Q32**	0.717
		Q9	0.691	**Q20**	0.596	**Q31**	0.646	**Q11**	0.655	**Q22**	0.760	**Q33**	0.591
		Q10	0.740	**Q21**	0.664	**Q32**	0.713	**Q12**	0.555	**Q23**	0.631		
		Q11	0.636	**Q22**	0.712	**Q33**	0.588						

Table 4. Loading factor in EFA

Step 1						Step 2					
Component						Component					
1		2		3		1		2		3	
Q8	0.804	**Q22**	0.783	**Q10**	0.808	**Q8**	0.810	**Q22**	0.819	**Q10**	0.816
Q16	0.795	**Q21**	0.770	**Q9**	0.758	**Q16**	0.802	**Q21**	0.794	**Q9**	0.781
Q15	0.778	**Q20**	0.722	**Q14**	0.552	**Q32**	0.785	**Q20**	0.656	**Q14**	0.536
Q32	0.775	**Q23**	0.616	**Q3**	0.508	**Q15**	0.784	**Q23**	0.639	**Q13**	0.503
Q27	0.771	**Q17**	0.548	**Q13**	0.490	**Q27**	0.768	**Q24**	0.547		
Q6	0.722	**Q18**	0.543	**Q25**	0.465	**Q6**	0.732	**Q18**	0.517		
Q4	0.720	**Q24**	0.517			**Q29**	0.721				
Q29	0.714	Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization.				**Q4**	0.718	Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization.			
Q7	0.697					**Q7**	0.701				
Q31	0.686					**Q31**	0.697				
Q33	0.660					**Q5**	0.672				
Q5	0.655					**Q33**	0.671				
Q30	0.635					**Q11**	0.646				
Q28	0.633					**Q26**	0.645				
Q26	0.629					**Q30**	0.644				
Q11	0.621					**Q28**	0.635				
Q2	0.562					**Q2**	0.571				
Q12	0.562					**Q12**	0.568				
Q19	0.485					**Q19**	0.494				
Q1	0.482										

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3.5. Phase 5 – Confirmatory factor analysis

The CFA analysis yielded two steps to achieve the required model fit in this phase. Starting with the first step, a CFA model (see Figure 2) was constructed based on the results of the EFA conducted in the previous phase. In this step, the first order was encoded with components 1 (F1), 2 (F2), and 3 (F3) for each statement item within these respective components. Subsequently, the second order was encoded with F4 for each component F1, F2, and F3.

The first step in this phase revealed that all the aspects required for CFA model fit showed unsatisfactory justification results (see Table 5). This indicates redundancy among the statement items within one component or with other components. Therefore, elimination based on high modification indices (MI) (see Table 6) in confirmatory factor analysis (CFA) is an appropriate approach to remove redundancy and enhance model clarity (Thakkar, 2020). In this step, a total of 17 statement items were eliminated due to having relatively high MI values and high covariances with other items (Thakkar, 2020). As a result, in the second step, 12 statement items were found to have been refined to reflect the components and constructs previously identified. The specification of components is as follows: six statement items for component 1, three statement items for component 2, and three statement items for component 3. In this second step, a well-fitting model was achieved, with $0 \leq \chi 2 \leq 2df$ ($0 \leq 57.523 \leq 102$), $0.05 \leq p \leq 1.00$ ($0.05 \leq 0.246 \leq 1.00$), $0 \leq \chi 2/df \leq 2$ ($0 \leq 1.128 \leq 2$), $0.95 \leq NFI \leq 1.00$ ($0.95 \leq 0.964 \leq 1.00$), $0.97 \leq CFI \leq 1.00$ ($0.97 \leq 0.996 \leq 1.00$), $0.95 \leq GFI \leq 1.00$ ($0.95 \leq 0.960 \leq 1.00$), $0.90 \leq AGFI \leq 1.00$ ($0.90 \leq 0.939 \leq 1.00$), and $0 \leq RMSEA \leq 0.05$ ($0 \leq 0.023 \leq 0.05$) falling into the "good fit" category.

Table 5. Model fit summary

Step 1			Step 2		
Model Fit		**Justification**	**Model Fit**		**Justification**
CMIN	1094.571	No Fit	CMIN	57.523	Good Fit
DF	374		DF	51	
P	0		P	0.246	
CMIN/DF	2.927		CMIN/DF	1.128	
GFI	0.761		GFI	0.960	
AGFI	0.722		AGFI	0.939	
NFI	0.814		NFI	0.964	
CFI	0.869		CFI	0.996	
RMSEA	0.091		RMSEA	0.023	

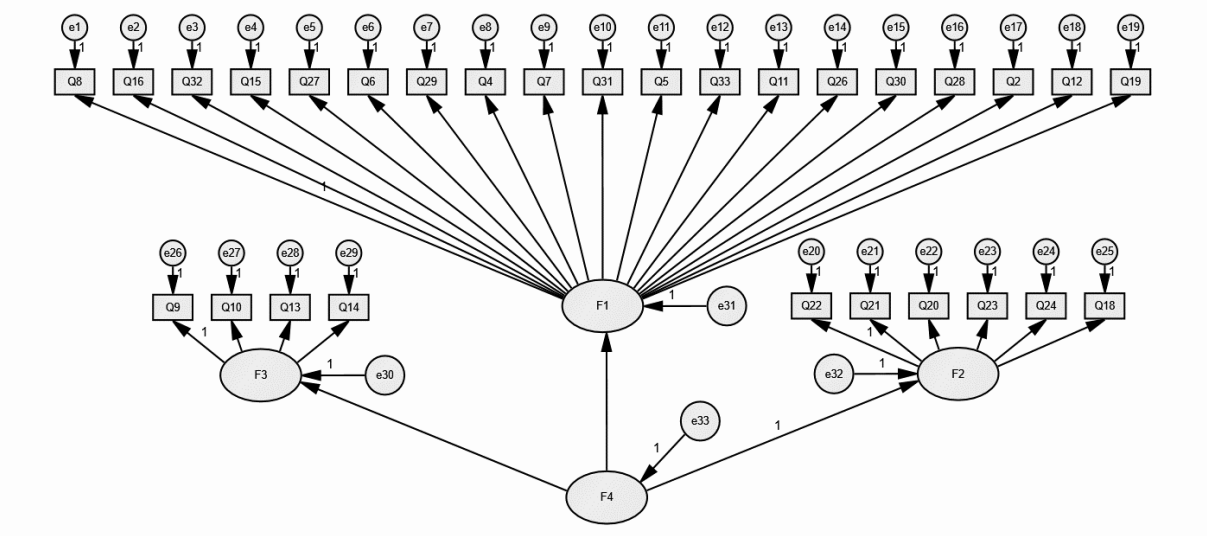

Figure 2. Model CFA step 1

Table 6. Covariances – Modification indices

			M.I.	Par Change				M.I.	Par Change				M.I.	Par Change
e29	↔	e31	7.772	0.072	e15	↔	e16	5.851	0.092	e6	↔	e10	4.194	−0.069
e27	↔	e30	7.129	0.112	e14	↔	e32	6.039	0.090	e6	↔	e9	1.567	0.111
e27	↔	e31	14.710	−0.145	e14	↔	e24	22.200	0.215	e6	↔	e8	14.192	0.119
e26	↔	e29	5.737	−0.117	e14	↔	e16	18.993	0.152	e6	↔	e7	7.269	−0.077
e26	↔	e28	6.414	−0.142	e14	↔	e15	16.926	0.138	e5	↔	e26	5.309	−0.099
e26	↔	e27	66.309	0.574	e13	↔	e30	12.770	0.107	e5	↔	e25	4.381	−0.088
e25	↔	e32	11.258	−0.164	e13	↔	e32	8.972	−0.124	e5	↔	e24	8.173	−0.130
e25	↔	e29	5.200	0.110	e13	↔	e27	9.045	0.171	e5	↔	e16	4.219	0.071
e24	↔	e30	6.339	0.099	e13	↔	e26	14.865	0.187	e5	↔	e14	4.056	0.062
e24	↔	e32	7.580	−0.147	e13	↔	e20	5.733	−0.123	e5	↔	e12	6.201	−0.093
e23	↔	e31	4.689	0.066	e12	↔	e15	7.417	0.111	e5	↔	e9	4.166	0.074
e23	↔	e26	4.085	−0.115	e11	↔	e30	16.296	0.104	e5	↔	e8	5.797	0.080
e22	↔	e29	5.792	0.147	e11	↔	e31	5.033	−0.050	e4	↔	e16	3.562	−0.181
e22	↔	e25	4.583	0.155	e11	↔	e29	7.806	0.095	e4	↔	e14	19.305	−0.127
e21	↔	e32	7.796	0.160	e11	↔	e26	5.992	0.102	e3	↔	e30	2.094	−0.121
e21	↔	e31	6.638	−0.096	e11	↔	e23	5.377	−0.091	e3	↔	e31	8.651	0.069
e21	↔	e25	6.112	−0.165	e11	↔	e16	4.885	0.074	e3	↔	e28	5.210	−0.093
e20	↔	e30	5.405	−0.091	e10	↔	e32	5.069	0.097	e3	↔	e27	7.888	−0.143
e20	↔	e32	7.737	0.146	e10	↔	e20	8.683	0.157	e3	↔	e12	12.952	0.136
e20	↔	e29	15.493	−0.205	e10	↔	e18	4.122	−0.096	e3	↔	e11	1.074	−0.095
e20	↔	e25	13.900	−0.229	e10	↔	e12	7.108	0.116	e3	↔	e10	7.441	0.099
e20	↔	e21	34.755	0.425	e9	↔	e26	5.312	−0.117	e3	↔	e7	18.803	0.133
e19	↔	e30	8.510	0.092	e9	↔	e25	1.087	−0.158	e3	↔	e4	5.798	0.070
e19	↔	e32	8.903	0.130	e9	↔	e23	6.242	0.120	e2	↔	e31	6.048	0.054
e19	↔	e31	17.710	−0.115	e9	↔	e18	4.782	0.105	e2	↔	e27	7.973	−0.136
e19	↔	e24	8.055	0.153	e9	↔	e10	6.621	−0.109	e2	↔	e22	7.811	−0.142
e19	↔	e22	4.278	0.130	e8	↔	e24	4.494	−0.105	e2	↔	e19	4.893	−0.077
e18	↔	e30	5.796	0.085	e8	↔	e14	5.227	−0.077	e2	↔	e15	5.030	−0.072
e18	↔	e31	4.286	−0.064	e7	↔	e30	1.740	−0.086	e2	↔	e4	7.645	0.076
e17	↔	e30	9.772	0.095	e7	↔	e32	5.986	0.089	e1	↔	e32	7.501	−0.097
e17	↔	e31	5.558	−0.063	e7	↔	e29	4.376	−0.073	e1	↔	e31	7.881	0.062
e17	↔	e29	4.048	0.081	e7	↔	e20	7.254	0.121	e1	↔	e21	5.617	−0.112
e17	↔	e27	5.031	0.130	e7	↔	e14	4.284	−0.063	e1	↔	e18	4.128	−0.079
e16	↔	e32	1.981	0.138	e7	↔	e10	5.879	0.086	e1	↔	e14	4.534	−0.063
e16	↔	e29	4.108	0.081	e6	↔	e25	7.102	0.105	e1	↔	e9	4.060	0.070
e16	↔	e26	7.610	−0.135	e6	↔	e20	12.182	−0.150	e1	↔	e3	9.015	0.089
e15	↔	e32	6.052	0.099	e6	↔	e12	7.355	−0.095	e1	↔	e2	9.216	0.085
e15	↔	e22	7.113	0.155										

Following the elimination of statement items, the second step of the CFA resulted in the model (see Figure 3). In the first order, the first component (F1) consists of the following statement items with their respective loading factors: Q2 (0.756), Q4 (0.748), Q12 (0.741), Q15 (0.870), Q16 (0.823), and Q33 (0.726). All of these statement items have loading factors falling into the high category. Moving to the second component (F2), it includes the following statement items along with their respective loading factors: Q18 (0.755) and Q21 (0.614), both of which have loading factors in the high category, and Q24 (0.692) with a loading factor also in the high category. The third component (F3) comprises the following statement items and their respective loading factors: Q9 (0.656), Q13 (0.776), and Q14 (0.797), all of which have loading factors in the high category (Hair et al., 2010).

The second-order model (see Figure 3) reveals that F1 (0.887), F2 (0.917), and F3 (1.023) have loading factors falling into the high to very high category (Hair et al., 2010) in reflecting F4 (see Table 7). This indicates that directly, the "first-order" statement items reflect their respective components (F1, F2, F3), and each of these components strongly reflects an overarching construct (F4) at the "second order."

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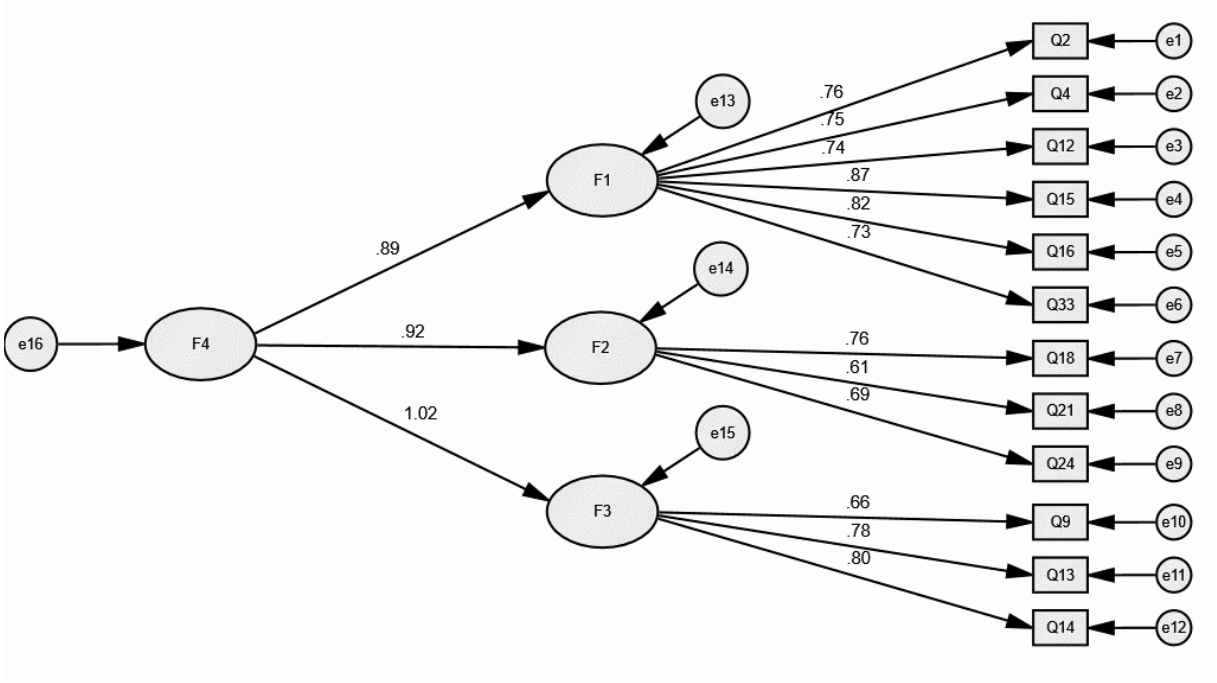

Figure 3. Model CFA step 2

Furthermore, after identifying 12 statement items with high robustness, each component reflected by these statement items is assigned an identity. The first component (F1) is identified as digital interpersonal skills, the second component (F2) as ideation and technology management skills, the third component (F3) as adaptation and innovation skills, and the overarching construct (F4) as digital entrepreneurial skills.

Based on the obtained results, the hypothesis is accepted. This means that the newly developed instrument for measuring digital entrepreneurship skills among university students is a valid and reliable tool capable of accurately assessing the competencies required for success in the digital entrepreneurship sector.

4. DISCUSSION

This study has identified 12 statement items that exhibit strong reliability as they have undergone correlation testing (Pearson, Kendall's, and

Table 7. Loading factor and identity of components

Category of Analysis	Step 1								Step 2			
	Estimate								Estimate			
First-Order Constructs	**Q8**	0.816	**Q7**	0.748	**Q28**	0.761	**Q23**	0.784	**Q2**	0.756	**Q18**	0.755
	Q16	0.824	**Q31**	0.778	**Q2**	0.722	**Q24**	0.672	**Q4**	0.748	**Q21**	0.614
	Q32	0.789	**Q5**	0.828	**Q12**	0.718	**Q18**	0.723	**Q12**	0.741	**Q24**	0.692
	Q15	0.841	**Q33**	0.753	**Q19**	0.714	**Q9**	0.708	**Q15**	0.870	**Q9**	0.656
	Q27	0.814	**Q11**	0.758	**Q22**	0.787	**Q10**	0.674	**Q16**	0.823	**Q13**	0.776
	Q6	0.845	**Q26**	0.793	**Q21**	0.738	**Q13**	0.77	**Q33**	0.726	**Q14**	0.797
	Q29	0.790	**Q30**	0.800	**Q20**	0.621	**Q14**	0.800				
	Q4	0.767										
Second-Order Constructs	**F1**	0.920							**F1**	0.887		
	F2	0.869							**F2**	0.917		
	F3	0.943							**F3**	1.023		
Identity of Components	**Code**	**Identity of Components**										
	F1	Interpersonal Digital Skills										
	F2	Ideation and Technology Management Skills										
	F3	Adaptation and Innovation Skills										
	F4	Digital Entrepreneurship Skills										

Spearman's), reliability analysis (alpha), exploratory factor analysis (KMO, anti-image, communalities, and loading factor), and confirmatory factor analysis (model fit and loading factor "first and second order"). Digital entrepreneurship skills (F4) are reflected in the first component (F1) of interpersonal digital skills with loading factor values >0.40 (.890), the second component (F2) of ideation and technology management skills with loading factor values >0.40 (.920), and the third component (F3) of adaptation and innovation skills with loading factor values >0.40 (1.020). This indicates that individuals possess a strong foundation in general entrepreneurial skills along with specific competencies required for success in an increasingly digital business environment.

Considering interpersonal digital skills (F1), this finding aligns with Asari et al. (2023), Gärtner et al. (2022), Pratscher et al. (2019), and Wolfer et al. (2020), who suggest that interpersonal skills emerge when individuals are aware of their own thoughts, emotions, feelings, bodily sensations, experiences, and intentions during interactions. Each statement item (Q2, Q4, Q12, Q15, Q16, and Q33) indicates such conditions in the digital era, hence giving this component the identity of interpersonal digital skills. These statements reflect various aspects, including digital interaction awareness (Q2), where individuals are comfortable with digital technology and likely have a broad and diverse social network (Blakemore & Agllias, 2020; Vallor, 2020). Awareness of business opportunities (Q4) shows an active attitude in seeking and considering the latest business opportunities on the internet, reflecting a willingness to stay informed and potential interest in entrepreneurship or business innovation (Okolie et al., 2021). Respecting others (Q12) indicates an individual's willingness not to impose their will on others, demonstrating maturity, respect for others' opinions and decisions, and the ability to work collaboratively in a cooperative environment (Klapper & Fayolle, 2023). Desire for learning (Q15) reflects an individual's willingness to learn and explore new things, indicating an open attitude, strong curiosity, and a commitment to personal development (Harrison, 2023; Vega-Gómez et al., 2020). Developing skills according to one's talents (Q16) shows an individual's desire to master various areas of expertise that align with their personal talents, indicating self-awareness of strengths and interests, as well as a desire to develop those potentials (Carden et al., 2021; DeMink-Carthew et al., 2020). Lastly, idea evaluation (Q33) indicates that individuals evaluate the ideas they propose, signaling critical and reflective abilities, which are crucial in the learning and innovation processes (Dabo, 2018; Din, 2020). These findings also support the notion that interpersonal skills are needed in today's digital media use (Blakemore & Agllias, 2020; Gutiérrez Ángel et al., 2022; Poláková et al., 2023; Zech et al., 2022).

Ideation and technology management skills (F2) are related to the perspective (Borges et al., 2021; Khumsamart, 2022; C. Marnewick & A. Marnewick, 2021) that in the development of technology, especially digital technology, skills are required to manage ideas to align with the utilization of existing technology. Translating ideas or inventions into products or services that create value or will be paid for by customers is crucial for entrepreneurship, both in existing businesses and new ventures (Hsieh & Wu, 2019). This component is reflected through several statement items, starting with the documentation of ideas (Q18), where the habit of writing down suddenly conceived ideas demonstrates reflective and creative habits. This reflects the ability to recognize and capture moments of inspiration (Stirzaker et al., 2021), which is important for the creative and innovation processes (Song & Wu, 2021). It also helps in developing these ideas into more concrete plans or projects. Effective financial management (Q21) indicates tracking all expenses over a specific period (daily, weekly, monthly, yearly), demonstrating discipline and good financial awareness (Ouachani et al., 2021). This is an essential skill for personal financial management and can also play a crucial role in business or project management (Babajide et al., 2023; Hasan et al., 2021). Deepening technological knowledge (Q24) signifies a deepening of knowledge in the field of technology, reflecting a commitment to learning and advancement in a rapidly changing and highly impactful area (Mansilla & Wilson, 2020).

Adaptation and innovation skills (F3) are an intriguing component (Bramwell et al., 2019; Harari et al., 2023; Szemző et al., 2022) in entrepreneurship, where the ability to adapt to societal changes

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and developments and produce innovative products is crucial. This is reflected through statement items indicating several aspects, starting with adaptability (Q9), which expresses ease in adapting to new environments, demonstrating flexibility, resilience, and openness to change (Harari et al., 2023; Szemző et al., 2022). This is an essential quality in a rapidly changing world, both professionally and personally. Being risk-oriented (Q13) reflects a willingness to take risks in work or tasks and show the courage to face uncertainty and the potential for innovation. It also reflects a proactive attitude in tackling challenges and a willingness to step out of one's comfort zone (Gurel et al., 2021). The desire to try new things (Q14), which indicates an interest in trying new things found on the internet, demonstrates strong curiosity, acceptance of learning and innovation, and the ability to leverage digital resources for personal and professional growth (Hameed & Irfan, 2019).

CONCLUSION

This study successfully identified 12 statement items that reflect strong digital entrepreneurial skills. This paper demonstrated the validity and reliability of the research instrument. Interpersonal digital skills encompass digital interaction awareness, comfort with technology, and the ability to leverage social networks. It is closely related to awareness of business opportunities, respect for others, a desire to learn, and the ability to critically evaluate ideas. Ideation and technology management skills emphasize the need to manage ideas in alignment with evolving technology. This component includes documenting ideas, financial management, and in-depth knowledge of technology. Adaptation and innovation skills are crucial in entrepreneurship, where the ability to adapt to changes and generate innovative products is highly necessary. This aspect includes flexibility, resilience, risk-taking courage, and a willingness to try new things. Overall, this study underscores that digital entrepreneurship skills encompass a combination of interpersonal skills, ideation, and technology management skills, as well as adaptation and innovation skills, all of which are vital in fostering success in today's digital era. The findings are expected to contribute to policymakers, educators, students, and other researchers as a fundamental part of developing students' skills, especially digital entrepreneurship skills.

AUTHOR CONTRIBUTIONS

Conceptualization: Chairul Huda Atma Dirgatama.
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Funding acquisition: Chairul Huda Atma Dirgatama.
Investigation: Chairul Huda Atma Dirgatama.
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Writing – original draft: Chairul Huda Atma Dirgatama.
Writing – review & editing: Chairul Huda Atma Dirgatama.

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