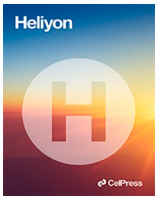
Heliyon 10 (2024) e33853

Contents lists available at ScienceDirect

Heliyon

journal homepage: www.cell.com/heliyon



Research article

Threat or prospect? Exploring the impact of digital entrepreneurs' artificial intelligence perception and intention to adopt blockchain technology on the achievement of SDGs

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ARTICLE INFO

Keywords:
Industry 4.0
Blockchain technology
Digital entrepreneurs
SDGs
Artificial intelligence

ABSTRACT

This paper explores how digital entrepreneurs' intention toward blockchain technology adoption, perception of reduced costs, and knowledge of Artificial Intelligence impact achieving UN's Sustainable Development Goals (SDGs), drawing attention from various sectors. Present study applies explanatory sequential mixed method for data collection. Moreover, to work with the dual face patterned data, PLS-SEM is used to perform quantitative analysis of the data collected from 389 digital entrepreneurs who are chosen through purposive sampling and then content analysis is performed for the qualitative data according to the explanatory sequential mixed method's rule of thumb. The study's quantitative phase shows that factors such as perceived ease of use and usefulness of Industry 4.0 technologies, knowledge of artificial intelligence (KAI), and perception of reduced cost positively influence digital entrepreneurs' intention to adopt blockchain technology (BCT). Notably, KAI has the strongest impact. In the qualitative phase, it's found that digital entrepreneurs' KAI and willingness to adopt BCT strongly align with achieving several UN Sustainable Development Goals (SDGs), suggesting BCT adoption's potential for sustainable outcomes. The outcomes of this study set a new benchmark in the domain of SDGs achievement with careful integration to Industry 4.0, AI and BCT. This study results undoubtedly instigate the digital entrepreneurs to adopt BCT in doing their start-up and convince the policymakers to set regulatory landscape with convenient environment for the utilization of BCT which then ultimately accelerates the achievement of SDGs.

1. Introduction

In March 2015, the United Nations (UN) set 17 Sustainable Development Goals (SDGs) with 169 multi-dimensional targets and 330 indicators through a comprehensive assembly in New York. After that, nations, leaders, industries, and entrepreneurs have been working on this mega target set by the UN utilizing their strengths through using dynamic strategies and visionary leadership. These 17 targets are connected to social, economic, and technological perspectives, sustainable cities and communities, and issues related to climate change and the environment which are prospectively to be achieved by 2030 [1]. Thus, more and more groundbreaking studies are highly expected on SDGs to support the UN in the achievement of its goals. On the other hand, Blockchain Technology (BCT) as one

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https://doi.org/10.1016/j.heliyon.2024.e33853
Received 6 December 2023; Received in revised form 26 June 2024; Accepted 27 June 2024
Available online 27 June 2024

of the key indicators in the revolution of Industry 4.0 in this era and Digital Entrepreneurship (DE) seeks the attention of various platforms in the national as well as international platforms. BCT and DE as the components of Industry 4.0 draw a meaningful insight to achieve the SDGs set by the UN.

With the exploration, modification, and beautification of various moods of businesses in the present time, digital platform-based startups still progress with high-profit margins. Instead of having multiple advantages of a digital startup, DE uplifts the entrepreneurial orientation and opportunity to make higher sales or to earn profit rather than other business models [2]. However, the digital business model still faces trust issues of online customers [3]; and difficulty to get access product review information [4]. Meanwhile, BCT has already started to take the position of safeguarding and trust toward the safe mode of operating multiple nodes (operating computers in the channel), promoting easy access to information, accelerating information traceability, and then protecting information from threat to hack [5]. Moreover, BCT offers its core advantages in the field of smooth supply chain [6,7]; efficient banking [8]; error-free health care service [9]; confirming stable and quick auditing [10], and many other fields of globalization. So, it is transparent now that BCT promotes the evolution of Industry 4.0 as well as might kill the disruption and other related negative issues from the heart of online business customers.

Previously, several significant researches were conducted on exploring the digital entrepreneurs' intention [11,12]; revealing BCT adoption intention [13]; on disclosing the impact of an individual knowledge of AI and perceived RC on their intention to adopt BCT [14], but there are still some eye-catching and noteworthy gaps to be filled, especially showcasing the digital entrepreneurs' intention to adopt BCT with the implication of Industry 4.0 perceived ease of use and usefulness, their knowledge and perception regarding AI and RC perception as well as predicting the effect of digital entrepreneurs' KAI and intention to adopt BCT on the achievement of UN SGDs with an application of TAM based mixed method approach.

The main objective of this study is to explore a clear research path for future researchers by conducting a rigorous investigation regarding the digital entrepreneurs' intention to use BCT in doing business incorporating multiple dimensions and predict its impact on the achievement of UN SDGs. The agenda of the current study integrates Industry 4.0 with the usage of AI in the field of digital business platforms and with sustainability also. Undoubtedly, the outcomes of this work will create meaningful insights for industry experts, policymakers, and academics.

Thus, the present study considers the following research questions and hopefully, the answers to the following questions might offer feasible solutions to the above-mentioned problems, and assist to fulfill the above-mentioned objectives.

Q1. Do digital entrepreneurs intend to adopt blockchain technology to run their traditional businesses and to survive in the competition?

Q2. Does the digital entrepreneurs' perception of Industry 4.0, and perceived reduced cost associated with BCT and artificial intelligence influence their willingness to adopt blockchain technology-based digital business?

Q3. Do the digital entrepreneurs' knowledge of AI and intention to adopt blockchain technology assist the UN in achieving SDGs?

This groundbreaking mixed method study highlights the digital entrepreneurs' willingness to adopt BCT with their perception of Industry 4.0 and clear understanding of AI, and this intention will predict the opportunity toward the achievement of sustainable development goals by the UN. The major strength of this rigorous study is to consider Industry 4.0 and AI to predict digital entrepreneurs' intention to adopt BCT and to work with UN SDGs.

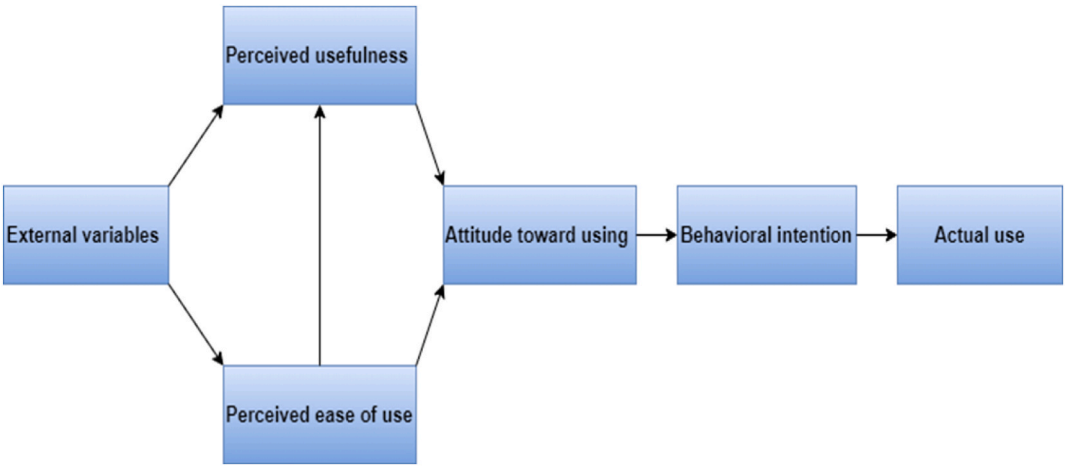

Fig. 1. TAM model developed by Davis [15].

2. Literature review and theoretical underpinning

2.1. Technology acceptance model

This study attaches the Technology Acceptance Model (TAM) to the theoretical section for developing and supporting the research framework of the study. Initially, TAM was developed by Davis [15] from the successful integration between Fishbein & Ajzen's [16] Theory of Reasoned Action (TRA) and Azen's [17] Theory of Planned Behavior (TPB). Historically, researchers apply TAM to investigate the new technology acceptance and usage intention of users or practitioners. This widely used model incorporates technology users' perceived ease of use and perceived usefulness to explore the new technology adoption intention. Perceived ease of use (PEOU) indicates the degree to which a user or practitioner has trust that new technology will be completely hassle-free or require less effort to get the job done [18]. Moreover, perceived usefulness denotes that technology users believe that the adoption of new technology will boost their productivity, effectiveness, efficiency, and performance [19].

Fig. 1 shows the TAM paradigm which adds an opportunity to offer theoretical support for the quantitative part of this study, and this well-accepted model precisely interprets the behavioral intention of digital entrepreneurs.

2.2. Industry 4.0 perceived ease of use (PEU) and digital entrepreneurs' intention to adopt BCT

Industry 4.0 perceived ease of use was not robustly investigated to know its impact on the entrepreneurs' intention to adopt BCT. However, Industry 4.0 PEU spells out the easiness of modern technology as well as using the approach to comply with the motto of digitalization [20]. Furthermore, Industry 4.0 ensures the optimum utilization of resources, achieving sustainability and low-cost manufacturing with quality maximization as well as promoting an easy way of completing jobs relating to manufacturing and supply chain [21–23]. One of the groundbreaking studies in this domain conducted by Cordero et al. [24] explored the positive and statistically significant effect of Industry 4.0 PEU on the Industry 4.0 attitude to use it. On the other hand, a few studies indicated earlier that PEU has a significant impact on e-government usage intention [25]; on internet service adoption intention [26]; and on e-wallet usage willingness [27]. To the best of the author's search, the is no mentionable study that exactly discloses the impact of Industry 4.0 PEU on the digital entrepreneurs' intention to adopt BCT. Therefore, to fill up this clearly identified literature gap, the present study hypothesizes the following statement:

H1. Industry 4.0 PEU has a positive impact on the digital entrepreneurs' intention to adopt BCT

2.3. Industry 4.0 perceived usefulness (PU) and digital entrepreneurs' intention to adopt BCT

Technology acceptance undoubtedly depends on the users' attitude regarding the benefits of adopting the technological product. When the individual or corporation understands the positive consequences of the utilization of a particular technology, then they might intend to accept and use it [15,28]. In line with the PU, Industry 4.0 PU denotes the users' sense of trust that the application of various components of Industry 4.0 such as Internet of Things (IoT), Cloud Computing, Augmented Reality (AR), Virtual Reality (VR), Artificial Intelligence (AI) and Robotics [29–32]; will enhances work performance and productivity [24]. Furthermore, researchers found a positive impact of PU on entrepreneurial willingness [33]; and on digitalizing small and medium enterprises [34]. Literature on Industry 4.0 PU is not vast enough to create a meaningful insight for policymakers, academics, and others. A significant study evidenced that Industry 4.0 PU has a significant statistical impact on the Industry 4.0 positive mindset to use [24]. To the best of the author's knowledge, there is no clear outcome in the association between Industry 4.0 PU and digital entrepreneurs' intention to adopt BCT. Thus, the current study develops the hypothesis as follows:

H2. Industry 4.0 PU has a positive effect on the digital entrepreneurs' intention to adopt BCT

2.4. Digital entrepreneurs' knowledge of artificial intelligence (KAI) and digital entrepreneurs' intention to adopt BCT

AI has become an essential part of human daily life such as performing jobs, exchanging information, and operating smartphones or computers. AI refers to the computer-integrated programs that are being developed to perform some cognitive functions such as interaction, communication, learning, and critical problem-solving [35].

On the other hand, knowledge indicates the combination of tacit and explicit information that will help the individual or corporation to make important decisions or to develop solutions for problems [36]. Literature in this domain elucidated that an individual's knowledge of AI has a significant affirmative connection with the intention to adopt BCT. Precisely, Individual human beings with a clear understanding of the usage, advantages, and demerits of AI applications might be willing to adopt BCT in SME [14]. Furthermore, AI boosts the quality of knowledge creation, acquisition, and sharing with others to reach a consensus or to come up with a new solution [37,38].Meanwhile, BCT accelerates the proper utilization of tacit and explicit knowledge from different perspectives [39]. Furthermore, studies on the integration between AI and BCT found some advantages such as AI boosting the quality and performance of BCT in terms of multi-nodes management systems, and information trackability [40,41]. Still, existing literature fails to explore the impact of digital entrepreneurs' knowledge of AI on their intention to adopt BCT. Specifically, there is no breaking-through study in the field of digital entrepreneurship to know the impact of knowing AI on adopting BCT. Thus, the present study postulates the following statement as one of the study's hypotheses:

H3. Digital entrepreneurs' KAI has a positive influence on their intention to adopt BCT

2.5. Digital entrepreneurs' perception of reduced cost and digital entrepreneurs' intention to adopt BCT

The application of BCT especially in the field of supply chain, manufacturing, transportation, medical service, education, or any other related sectors reduces costs and uplifts performance [42]. On the other hand, a comprehensive quantitative study has revealed an interesting statistical result that individual perception of reduced costs has an insignificant and negative impact on the willingness to adopt BCT [43]. Moreover, to the best of the author's search, existing literature still does not have any rigorous study on digital entrepreneurs' attitudes and mindset to adopt BCT. So, it is now crystal clear that there is a contradiction and something untouched in the relationship between the perception of reduced cost and BCT adoption desire. To unfold the contradictory issue in this context and to make the literature more robust, this work develops the following hypothesis:

H4. Digital entrepreneurs' perception of reduced cost has a positive influence on their intention to adopt BCT

Based on the above-discussed literature followed by three major study objectives to solve the research problems, authors propose a study model encompassing the quantitative and qualitative phases of the study. The research model is as follows (Fig. 2):

After conducting a literature review, it has become apparent that there are several gaps in the existing research on digital entrepreneurs' adoption of Blockchain Technology (BCT). Firstly, there is a lack of research in this domain from the perspective of digital entrepreneurs' perception regarding Industry 4.0, AI, and cost reduction. Secondly, there is a methodological gap in this domain since this study employs a TAM-based explanatory sequential mixed method approach to offer support for the conceptual framework. Thirdly, there is a country gap since there was no significant study on digital entrepreneurs' intention to adopt BCT in the context of Bangladesh. Lastly, there is a theoretical gap in the current literature since there was no noteworthy research to investigate the impact of digital entrepreneurs' BCT adoption intention, KAI, and perception of RC on the achievement of Sustainable Development Goals (SDGs).

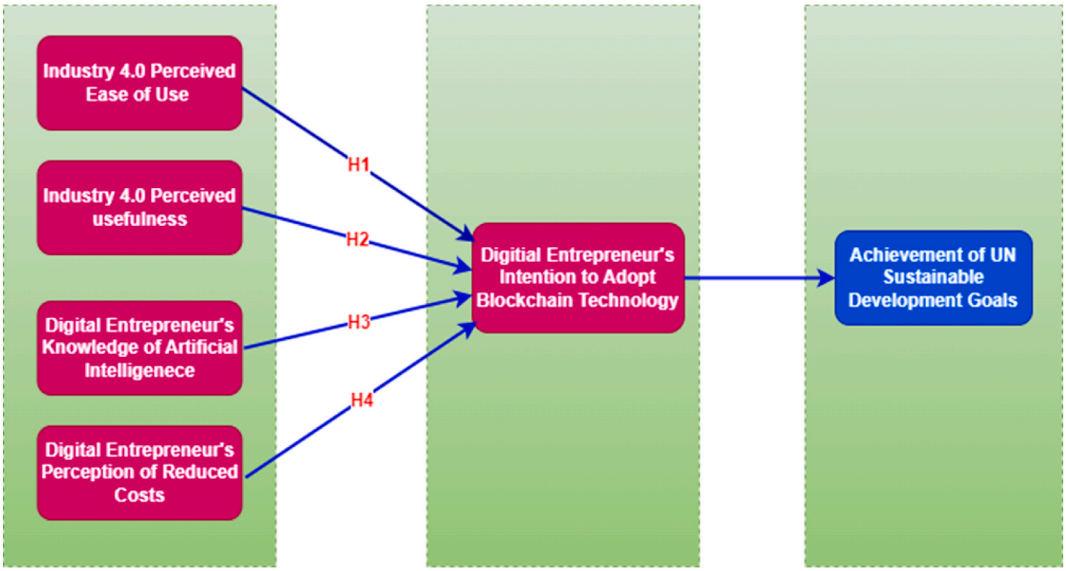

Fig. 2. Research model.

Table 1
Digital entrepreneurs' demographic profile.

Constructs	Characteristics	Frequency	Percent	Valid Percent
Gender	Male	247	63.50	63.50
	Female	142	36.50	36.50
Marital Status of Participants	Unmarried	120	30.85	30.85
	Married	269	69.15	69.15
Educational Level	Higher Secondary	40	10.28	10.28
	Honor's	231	59.38	59.38
	Masters	105	27	27
	Mphil/PhD	13	3.34	3.34
Age	18–30 Years	123	31.62	31.62
	31–40 Years	266	68.38	68.38

3. Methods

The present study applied the most appropriate methods and instruments such as SmartPLS or explanatory sequential mixed method design for data collection, analysis and interpretation which completely satisfy the latest research trends in the academia. Meanwhile, complex relationships between variables were frequently the subject of mixed-method research, which may not be sufficiently captured by conventional statistical techniques. In order to evaluate the intricate relationships between the variables, SmartPLS offered strong tools for evaluating the validity and reliability of measurement devices used in the collection and analysis of quantitative and qualitative data.

3.1. Research design

The present study employed a mixed-method approach that combines qualitative and quantitative method of data collection. The intent for applying this stereotype method of study was to discover the deeper insights on the study implications. Precisely, the current study used the "explanatory sequential mixed method design" or "two-phase model' [44]. This approach involved gathering quantitative data first and then using qualitative data to support and explain the quantitative results. The study focused on flipped learning in Istanbul and uses semi-structured interview data to support the quantitative data obtained through the five-point Likert scale [45]. When conducting mixed method research, a five-point Likert scale was treated as a quantitative tool for effectively capturing attitudes and opinions, as well as its limitations in fully capturing the complexity of human experiences. Adding qualitative methods to improve the validity and depth of research findings, which leads to a more thorough understanding of the phenomenon being studied.

3.2. Sampling and data collection

3.2.1. Quantitative phase

The study used purposive sampling [46,47] to select respondents from digital entrepreneurs who initiated their businesses in Bangladesh through information and communication technology-based online platforms – a new business model in emerging economic countries. After a thorough literature review, a structured questionnaire was developed using a five-point Likert scale and Google Forms to measure various constructs of the conceptual framework. The Google Form [48] was shared with the targeted respondents through virtual platforms [49] including Email, WhatsApp, Facebook Messenger, and among others. As part of purposive sampling, targeted respondents' email addresses were used to make the logs then link of the questionnaire was sent to all the email addresses. Most of the domain was the google mail services. Data were collected from May 2023 to July 2023, and the Google Form was kept open for all respondents with the option to edit their responses. A total of 399 responses were received, and after initial screening, 389 responses were finalized for further statistical analysis.

3.2.2. Respondents' profile

Table 1 displays that from the total of 389 gathered responses, 247 (63.50 %) are contributed by male participants, while 142 (36.50 %) originate from female participants. In terms of marital status, 120 respondents are single, making up 30.85 % of the total, whereas 269 respondents are married, constituting 69.15 % of the total. Regarding educational attainment, the predominant category among respondents is those with a honors degree (59.38 %), followed by those with a master's degree, representing 27 % of the total responses. Furthermore, 10.28 % of respondents have completed their higher secondary level, whereas only 3.34 % possess an MPhil/Ph.D. degree. Examining respondents' age, the data analysis indicates two age groups: 31.62 % (123) of respondents fall within the 18–30 age bracket, while 68.38 % (266) belong to the 31–40 age range.

3.2.3. Qualitative phase

This study collected qualitative data using the content analysis method which was being used in the field of pure qualitative and mixed method approach. Content analysis is a systematic approach to analyzing, synthesizing, and categorizing the textual data from the existing work in the related domain [50]. It entails looking for patterns, themes, and meanings in the text of books, media, and other kinds of communication. The attitudes, convictions, and perspectives of the people or groups represented in the data can be found through content analysis. Placing the data in a broader context helps to shed light on the cultural, social, and historical factors that have shaped the content. Mainly, the present study gathered qualitative data from three perspectives such as the impact of digital entrepreneurs' knowledge of AI and intention to adopt BCT on the achievement of SDGs.

3.3. Measurement technique

3.3.1. Quantitative phase

Existing literature on the study domain was considered the main focal point to measure the multiple constructs of the study. Items used to measure the variable were directly adopted and partially adapted to fit the current study pattern. All of the items used to measure the variable ranged from strongly agree to strongly disagree with the five-point Likert scale approach. Questionnaire items considered to measure industry 4.0 perceived ease of use and usefulness were adopted from groundbreaking research [24,28]. Furthermore, digital entrepreneurs' knowledge of AI and digital entrepreneurs' intention to adopt BCT as the study variables were measured through four items which are adapted [14]. On the other hand, digital entrepreneurs' perception of reduced cost was measured with four questionnaire items adapted from a rigorous study [43].

3.4. Data analysis

Since the current study uses the explanatory sequential mixed method of study design, it needs to execute two separate forms of data analysis tactics.

3.4.1. Quantitative analysis

For the quantitative data collected through a structured questionnaire, PLS-SEM [51] is applied to hit the rigorous statistical analysis.

3.4.2. Qualitative analysis

On the other hand, content analysis [52] technique is followed to analyze the qualitative data.

4. Data analysis and result interpretation

4.1. Quantitative phase

4.1.1. Common method bias test

The current study applies Harman's Single Factor test [53,54] to assess the common method bias (CMB) since it utilizes self-administered questionnaires to collect responses on exogenous and indigenous constructs from similar participants. Following, common method bias guidelines, the variance of extraction sum of square loading should be less than 50 % for the dataset to be appropriate for both descriptive and inferential statistics [19,54], Our analysis indicates that only 25.78 % of the variance in the dataset is attributable to multiple dimensions and variables. Consequently, we conclude that the screened dataset of 389 samples is entirely free from bias, demonstrating the potential for statistically valid descriptive and inferential analyses.

4.1.2. Goodness of fit measurement, reliability and convergent validity

In addition to using SmartPLS 4.0.9.2 to conduct descriptive and inferential analysis using the PLS-SEM modeling technique for the measurement and the structural model of the conceptual research framework of the study, this study uses SPSS-23 to clean up the data set in preparation for further analysis.

Table 2 examines how the eliminated set of data satisfies the threshold value, making it an ideal fit for PLS-SEM analysis. The analytical results demonstrate that the normed fit index (NFI) is 0.919, which is extremely close to 1, and the standardized Root Mean Square Residual (SRMR) of the proposed model is 0.069, which is less than the criterion of 0.08 [55,56].

Table 3 presents the results concerning the convergent validity, internal consistency, and multicollinearity position of the measurement models, assessed through factor loadings, Cronbach alpha (CA), composite reliability (CR), average variance extracted (AVE), and variance inflation factor (VIF). Items with factor loadings ranging from 0.70 to 0.94 [57], are considered well-positioned to measure a specific latent variable. After eliminating items that fall below this threshold, the factor loading column in Table 3 displays the selected items.

The absence of multicollinearity in the dataset is affirmed by VIF values for all items used in measuring latent variables, consistently meeting the specified threshold (VIF <5) [58]. The reliability of the measurement model is assessed through CR and CA, while the convergent validity of multiple measurement models within the conceptual framework is confirmed using AVE. Literature in this field established the acceptable thresholds for (CR and CA >0.70) and (AVE >0.50) [59]. Table 3 scrutinizes whether all latent variables meet these criteria, ensuring the assessment of the convergent validity and reliability of the model. Additionally, these findings suggest a complete alignment between the measurement model and the structural model of the study [60].

4.1.3. Discriminant validity of measurement model

This research investigates the discriminant validity of measurement models using three widely employed parameters: the Fornell-Larcker threshold, the Heterotrait-Monotrait ratio (HTMT) matrix, and item cross-loading. As indicated in Table 4, the latent variables exhibit Average Variance Extracted (AVE) values surpassing the correlations between variables [61]. Additionally, a measurement model's discriminant validity requires a threshold of 0.9 according to the HTMT criteria [62]; Table 5 illustrates that each construct successfully meets this criterion with nonbolded value. To further validate discriminant validity, item cross-loading is employed,

Table 2
Goodness of fit index.

	Saturated Model	Estimated Model
SRMR	0.058	0.069
d_ULS	1.673	1.961
d_G	0.401	0.436
Chi-Square	794.516	810.521
NFI	0.806	0.919

Note: NFI- Normed fit index; SRMR- Standardized Root Mean Square Residual.

Table 3
Convergent validity, internal consistency and multicollinearity.

Latent Variable and Sources	Items	FL	VIF	CR	AVE	CA(α)
Industry 4.0 Perceived Ease of Use (PEU) [24];	PEU01	0.853	1.922	0.828	0.617	0.726
	PEU02	0.719	1.134			
	PEU03	Delete	N/A			
	PEU04	Delete	N/A			
	PEU05	0.779	1.831			
Industry 4.0 Perceived Usefulness (PU) [24];	PU01	0.785	1.551	0.879	0.592	0.829
[28];	PU02	0.804	2.033			
	PU03	0.722	1.602			
	PU04	0.719	1.527			
	PU05	0.813	1.976			
Digital Entrepreneurs' Knowledge of AI (KAI) [14];	KAI01	Delete	N/A	0.867	0.686	0.771
	KAI02	0.818	1.718			
	KAI03	0.870	1.811			
	KAI04	0.795	1.404			
Digital Entrepreneurs' Perception of Reduced Costs (RC) [43];	RC01	0.796	1.385	0.884	0.717	0.803
	RC02	0.886	2.386			
	RC03	0.856	2.322			
	RC04	Delete	N/A			
Digital Entrepreneurs' Intention to Adopt BCT (IA) [14];	IA01	0.726	1.502	0.860	0.606	0.782
	IA02	0.809	1.626			
	IA03	0.747	1.496			
	IA04	0.826	1.865			

Note: FL- Factor loading; AVE: Average variance extracted; CR- Composite reliability; CA- Croanbach alpha; IA- Digital entrepreneurs' intention to adopt blockchain technology; KAI- Digital Entrepreneurs' knowledge of artificial intelligence; PEU- Industry 4.0 perceived ease of use; PU- Industry 4.0 perceived usefulness; Deletion of RC04, KAI01, PEU03, and PEU04: These four items were discarded from the measurement model since the factor loadings of these items fall below the threshold 0.70.

Table 4
Fornell-Larcker criterion.

	IA	KAI	PEU	PU	RC
IA	**0.778**				
KAI	0.891	**0.828**			
PEU	0.858	0.696	**0.786**		
PU	0.833	0.789	0.679	**0.770**	
RC	0.808	0.596	0.881	0.700	**0.847**

Note: IA- Digital entrepreneurs' intention to adopt blockchain technology; KAI- Digital Entrepreneurs' knowledge of artificial intelligence; PEU- Industry 4.0 perceived ease of use; PU- Industry 4.0 perceived usefulness.

Table 5
Item cross-loading and Heterotrait - monotrait ratio (HTMT) – matrix.

	IA	KAI	PEU	PU	RC
IA1	**0.726**	0.771	0.827	0.786	0.751
IA2	**0.809**				
IA3	**0.747**				
IA4	**0.826**				
KAI2		**0.818**	0.765	0.714	0.797
KAI3		**0.870**			
KAI4		**0.795**			
PEU1			**0.853**	0.794	0.710
PEU2			**0.719**		
PEU5			**0.779**		
PU1				**0.785**	0.865
PU2				**0.804**	
PU3				**0.722**	
PU4				**0.719**	
PU5				**0.813**	
RC1					**0.796**
RC2					**0.886**
RC3					**0.856**

Note: IA- Digital entrepreneurs' intention to adopt blockchain technology; KAI- Digital Entrepreneurs' knowledge of artificial intelligence; PEU- Industry 4.0 perceived ease of use; PU- Industry 4.0 perceived usefulness.

revealing also in Table 5 with bolded value that all items are strongly loaded within their respective constructs but weakly loaded on other constructs [63,64].

4.1.4. Analysis of structural model

To establish the direct correlation between latent variables, the present research employs a bootstrapping PLS-SEM computational method with a resampling strategy of 5000 iterations, as outlined and experimented by several studies [65–67]. Fig. 3 illustrates the graphical representation of the structural equation modeling.

Table 6 displays the result of hypotheses testing with individual acceptance and rejection status. The previously mentioned PLS-SEM bootstrapping method produces results regarding several direct paths among the latent variables connected to multiple structural models of the conceptual framework. Table 6 notifies us that digital entrepreneurs' Industry 4.0 PEU positively affects their intention to adopt BCT with expected parameters of $\beta = 0.238$; Std Error = 0.042; t = 0.5711 and P = 0.000 and this result supports hypothesis 1. On the other hand, the finding regarding the association between digital entrepreneurs' Industry 4.0 PU and their intention to adopt BCT accepts hypothesis 2 because this connection generates standard results with $\beta = 0.134$; Std Error = 0.026; t = 5.082 and P = 0.000. Furthermore, the study result in this section supports hypothesis 3, since the PLS-SEM outcome fulfills all criteria for the effect of digital entrepreneurs' KAI on willingness to adopt BCT with $\beta = 0.495$; Std Error = 0.026; t = 19.392 and P = 0.000. Lastly, the analytical results demonstrate that digital entrepreneurs' RC has a positive and statistically significant impact on their desire to adopt BCT with $\beta = 0.210$; Std Error = 0.046; t = 4.544 and P = 0.000, which then supports hypothesis 4. So, the current study results strongly evidence that all of the hypothetical impacts of independent variables on dependent variables are statistically significant and positive in terms of beta, standard error, t-value, and p-value which then ultimately creates an absence of hypothesis rejection.

The study's findings satisfy the criterion of $R2 > 0.02$, confirming the predictability of the dependent variable [68] by the independent variables with an immediate impact, as illustrated in Fig. 4. This outcome indicates that digital entrepreneurs' intention to adopt BCT, considered an endogenous variable, is effectively anticipated by each of the four exogenous variables. Consequently, this suggests a perfect fit between the model and the dataset [69].

4.2. Qualitative phase

This section of this scientific paper tries to deal with analyzing qualitative data as the explanatory sequential mixed method was applied to collect and analyze the data. As the standard of the explanatory sequential mixed method [70], qualitative data is needed to give support for the quantitative phase which is already done in this paper.

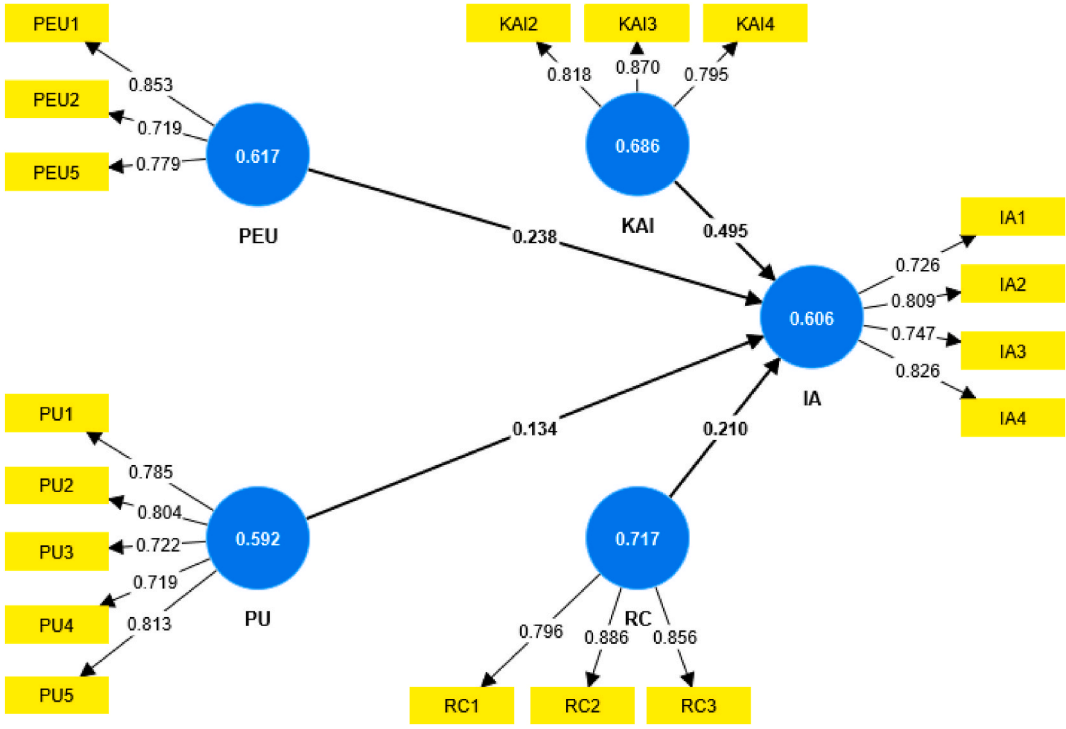

Fig. 3. Structural equation model. **Note:** IA- Digital entrepreneurs' intention to adopt blockchain technology; KAI- Digital Entrepreneurs' knowledge of artificial intelligence; PEU- Industry 4.0 perceived ease of use; PU- Industry 4.0 perceived usefulness.

Table 6
Results for hypothesis testing.

Hypotheses	Paths	Beta (β)	Std. Error	t-value	p-value	*Status*
H1	PEU→ IA	0.238	0.042	5.711	0.000	*Supported*
H2	PU→ IA	0.134	0.026	5.082	0.000	*Supported*
H3	KAI→ IA	0.495	0.026	19.392	0.000	*Supported*
H4	RC→ IA	0.210	0.046	4.544	0.000	*Supported*

Note: IA- Digital entrepreneurs' intention to adopt blockchain technology; KAI- Digital Entrepreneurs' knowledge of artificial intelligence; PEU- Industry 4.0 perceived ease of use; PU- Industry 4.0 perceived usefulness.

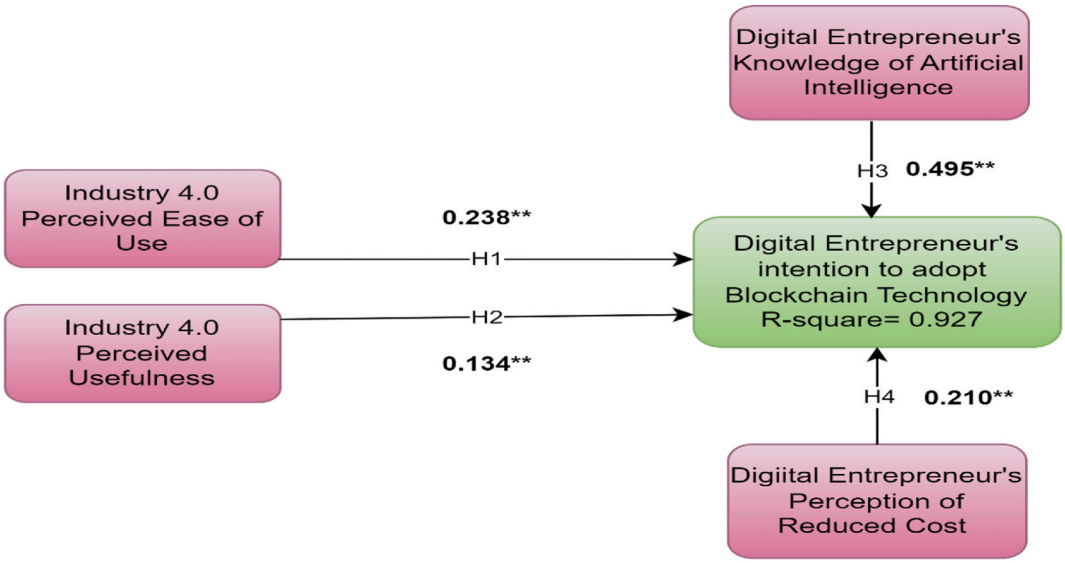

Fig. 4. Results of structural equation model.

The present study follows the content analysis method to analyze the qualitative data. Content analysis assists the researchers in summarizing the outcomes from several forms of research such as original scientific articles, systematic review articles, book chapters, or related magazines [71]. Moreover, content analysis is used to methodically examine the textual, auditory, visual, and social media content of a variety of communication mediums. Finding and interpreting patterns, themes, and trends in the content under analysis is its main goal. By interpreting the data in light of the research question and larger context, content analysis comes to conclusions, draws inferences, and discusses implications.

To come up with unique solutions to the earlier mentioned research problems and to figure out the answer to all the research questions, currently this work focuses on the existing published works on exploring the impact of digital entrepreneurs' intention to adopt BCT and digital entrepreneurs' KAI on the achievement of several sustainable development goals by UN.

4.2.1. Digital entrepreneurs' KAI accelerates the achievement of SDGs

Literature on this domain strongly demonstrates that the application of artificial intelligence has a noteworthy impact on the fulfilment of SDGs. Recently, a scientific study [72] evidenced that application of various phases of AI such as deep learning, promotes the achievement of SDG3, SDG4, SDG7, SDG11, SDG13, and SDG16. Whereas, "SDG3 relates with ensuring healthy lives and promoting well-being for all at all ages"; "SDG4 relates with ensuring inclusive and equitable quality education and promoting lifelong learning opportunities for all"; "SDG7 spells out ensuring access to affordable, reliable, sustainable and modern energy for all"; "SDG11 connects with making cities and human settlements inclusive, safe, resilient and sustainable"; "SDG13 involves with taking urgent action to combat climate change and its impacts"; and "SDG16 concerns with promoting peaceful and inclusive societies for sustainable development, providing access to justice for all and building effective, accountable and inclusive institutions at all levels". Furthermore, a systematic review paper that covered the period between 2017 and 2022 and, its outcome transparently found that the application of AI has a significant impact on achieving SDGs but AI requires global ethical standards, compliance, and regulatory actions [73]. Moreover, knowledge, awareness, and practice of AI strengthen the business competitiveness and success toward the achievement of SDGs [74–78].

So, the above research summary, from the previous findings, demonstrates that digital entrepreneurs with AI knowledge, AI acceptance, and AI positive attitude might accelerate the achievement of several sustainable development goals set by the UN. And, this content analysis-based synopsis supports the results obtained from quantitative data analysis.

4.2.2. Digital entrepreneurs' intention to adopt BCT pushes the achievement of SDGs

Blockchain technology adoption in various fields such as supply chain, medical services, online seat reservation, and banking systems promotes the achievement of the sustainable goal set by the UN. A rigorous study in this field denoted that blockchain can achieve traceability, provenance tracking, transparency, and reduce environmental impact in the food supply chain [79]. It also helps in achieving sustainable development goals set by the UN. Precisely, this finding supports the achievement of SDG3 which incorporates the initiatives for "ensuring healthy lives and promoting well-being for all at all ages". On the other hand, another study found the adoption of BCT as one of the key indicators that foster the achievement of gender equality and it demonstrates the fulfilment of SDG5 which involves "achieving gender equality and empowering all women and girls" [80]. Moreover, several rigorous studies exploring the impact of BCT adoption in the field of business, medical service, supply chain, and banking on the achievement of SDGs set by UN in March 2015 and most of the study's outcomes elucidate that the application of BCT promotes the achievement of SDG1, SDG3, SDG5, SDG9, and SDG12 [81]; SDG16 [82]; SDG10 [83]. Furthermore, the adoption and usage of BCT assist the UN in fulfill the two of its major goals out of 17 SDGs such as zero hunger (SDG2) and clean water and sanitation (SDG6).

Broadly speaking, the application of these advanced technological disruptions opens the dynamic window for the UN to achieve its 17 goals, and 169 targets with 330 indicators by 2030. Undoubtedly, digital entrepreneurs with the willingness to adopt BCT might demonstrate the potential to fulfill several SDGs set by the UN to protect the environment and ensure sustainability.

5. Discussion

For the proper solution to the complex problems that existed in the rigorous literature review sections of this study, an explanatory sequential mixed method of inquiry is applied, especially for data collection and analysis. According to the study design, results are interpreted with two separate phases in the earlier section. The discussion part of the study is also categorized into three sections given in below:

5.1. Discussion for quantitative results

The PLS-SEM outcomes highlight the results regarding several hypotheses around multiple structural models in the conceptual framework. The statistical outcome obtained with PLS-SEM of this groundbreaking research demonstrates that digital entrepreneurs' Industry 4.0 PEU has a statistically significant effect on their willingness to adopt BCT, and the previous work in this domain supports this finding partially [24] and supports hypothesis 1. This finding clearly addresses the first question of this study, which focused on digital entrepreneurs' intention to use BCT. Additionally, it aligns with the results of several recently published significant works in this domain [84,85]. Elaborately writing that when digital entrepreneurs perceive that using BCT is completely hassle-free, then they intend to adopt BCT in doing their computer technology-based new venture. The direct path testing results also supports hypothesis 2, which found a positive and statistically significant influence of digital entrepreneurs' Industry 4.0 PU on their BCT application intention. The existing literature in this field closely views and cooperates with this outcome [24],[33],[34]. Furthermore, previously conducted significant studies reported similar outcomes in this domain, which also addresses the first question of this insightful and novel work[86,87]. Users' perceived usefulness of new technology clearly stimulates their desire to accept and adopt it for daily life or business activities [88–90]. This finding highlights that digital entrepreneurs' intention to apply BCT will be high if they believe that adopting BCT boosts their productivity and performance. The outcome of this comprehensive mixed method research offers support for hypothesis 3, which evidences that digital entrepreneurs' KAI has a substantial impact on their BCT adoption desire from the entrepreneurial intention. And, this result is perfectly supported by the previous works on revealing the impact of entrepreneurs' AI knowledge, perception, and acceptance on their willingness to accept and use BCT [14],[39]. Additionally, the analysis of structural equation modeling focused on hypothesis 3 produces results that are consistent with the existing quantitative findings of this study [91–93]. Meanwhile, this finding thoroughly addresses the first and second research questions of this study. Broadly speaking, a digital entrepreneur equipped with proper tacit and explicit knowledge of AI, shows a positive intention to carry on digital start-up with BCT. The bootstrapping result of this work also supports hypothesis 4, which demonstrates the positive and statistically significant impact of digital entrepreneurs' perception of RC on their intention to adopt BCT and this result clarifies the contradiction that existed in the literature as well as supports the result of previous works [42,43]. One more thing hereby denotes that when digital entrepreneurs think that doing business with the adoption of BCT reduces the cost of carrying venture, they might show their positive willingness to adopt BCT. Several recent studies have indicated that using BCT to ensure smooth and secure business transactions incurs lower costs compared to traditional transactional methods [94–96]. Hence, this result satisfies the hypothesis 4 and successfully responds to the second question of this study.

Precisely, the PLS-SEM model employs four independent variables and one dependent variable, where the path testing finding evidence that out of four independent variables, digital entrepreneurs' KAI has the most significant impact on their adoption intention of BCT for their digital start-up.

5.2. Discussion for qualitative results

To give support for the quantitative results, the present study analyzes qualitative data with content analysis techniques. The qualitative phase of analysis evidences that digital entrepreneurs' KAI accelerates the achievement of SDGs set by the UN [72,74–76]. More broadly, literature in this field found a parallel relationship between digital entrepreneurs' KAI and fulfilling SDGs, especially SDG3, SDG4, SDG7, SDG11, SDG13, and SDG16, which were previously set by the UN to be achieved by 2030.

Another part of qualitative data analysis highlights that digital entrepreneurs' intention to adopt BCT promotes the achievement of several SDGs by the UN [81–83]. Actually, BCT adoption intention supports all most 9 goals including SDG1, SDG2, SDG3, SDG5, SDG6 SDG9, SDG10, SDG12, and SDG16. Therefore, the content analysis spells out that digital entrepreneurs'' intention to adopt BCT has a noteworthy impact on achieving almost all the goals set by the UN. Consequently, the findings from the qualitative study thoroughly address the third research question, which focused on examining the effect of digital entrepreneurs' KAI and BCT adoption intentions on the accomplishment of SDGs.

5.3. Combining the analytical results obtained from quantitative and qualitative phase

In this section of the study, we combine the results obtained from both the quantitative and qualitative analyses. The study uses four independent variables to determine digital entrepreneurs' intention to adopt BCT. The hypotheses testing results show that each independent variable has a statistically significant impact on the dependent variable. More specifically, digital entrepreneurs' Industry 4.0 PEU, Industry 4.0 PU, KAI, and RC have successfully determined their intention to adopt BCT. The qualitative results strongly support the quantitative findings. The study found that digital entrepreneurs' KAI and BCT adoption intention, as measured quantitatively, have a positive effect on the achievement of several SDGs by the UN. Therefore, the mixed method approach used in this study highly justifies the integration between qualitative and quantitative results.

5.4. Theoretical implication

The study design and the outcomes undoubtedly offer noteworthy insights into the existing literature from the theoretical perspective. Firstly, the present study applies an explanatory sequential mixed method approach for the first time, especially in the Industry 4.0-digital entrepreneurship-SDGs domain, to investigate the impact of digital entrepreneurs' Industry 4.0 PEU, Industry 4.0 PU, KAI, and RC on the achievements of SDGs by UN through measuring their intention to adopt BCT to proceed their digital business further. Therefore, there is a clear novelty in the methodological outcome of the research. Secondly, the present study integrates Industry 4.0, digital entrepreneurship, and sustainability development goals in a single bottle of a rigorous study, and to the best of the author's search, there is no significant study that covered these hotcakes of globalization at a time. Thus, this work shows great insights into the existing literature. Thirdly, this comprehensive study investigates the digital entrepreneurs' perception of Industry 4.0, knowledge of artificial intelligence, and perception of reduced costs in adopting BCT, which was not investigated earlier in a single conceptual framework. Finally, the present study creates a future research agenda in this domain since currently, we fail to measure the achievement of UN SDGs as a construct with quantitative measurement scales and consider qualitative data for the variable.

5.5. Managerial implication

The qualitative and quantitative analysis phases provide meaningful insights and notifications for the industry, academics, and policymakers. The findings of this study can help policymakers understand the importance of adopting Blockchain Technology (BCT) in digital entrepreneurship to achieve the Sustainable Development Goals (SDGs). This understanding can lead to the creation of a regulatory landscape and innovation-friendly culture surrounding blockchain for digital entrepreneurs. When digital entrepreneurs have a convenient environment to apply BCT with legal support, they will be more inclined to proceed with their startups, which can help the United Nations achieve its 17 goals by 2030. The research emphasizes the importance of adopting a long-term perspective while integrating blockchain technology. Digital entrepreneurship managers should see blockchain as a transformative tool that, when aligned with sustainable development goals, can contribute to lasting positive change rather than a short-term solution.

6. Conclusion, limitations, and future directions

Using the Technology Acceptance Model and an explanatory sequential mixed-method approach, this study examines how various factors, including digital entrepreneurs' perception of Industry 4.0, KAI, perceived cost savings, and the intention to adopt BCT, impact the likelihood of achieving the UN SDGs. The study focuses on qualitative data obtained through content analysis to support quantitative data gathered via structural equation modeling. This study provides evidence that the adoption of blockchain technology by digital entrepreneurs, influenced by factors such as ease of use, perceived cost reduction, and robust knowledge of AI, has a significant impact on the achievement of the UN's Sustainable Development Goals (SDGs). The integration of Industry 4.0 technologies, particularly BCT and AI, can be a powerful tool in fostering sustainable outcomes, encouraging digital entrepreneurs to adopt these innovations while prompting policymakers to establish supportive regulatory frameworks. The findings highlight the transformative potential of leveraging Industry 4.0 technologies for sustainable development, paving the way for a future where innovation and global goals align.

Academic or applied research cannot exist without constraints. This study, like many others, both qualitative and quantitative, has some limitations. Firstly, the current study does not encompass multiple countries or regions; rather, it only emphasizes national perspectives regarding the intention of digital entrepreneurs to adopt BCT. Secondly, the authors do not take into account other factors like effort expectancy or social influence when predicting the behavioral intention of digital entrepreneurs. Instead, they solely use the PEU and PU of industry 4.0. Thirdly, by excluding a single control variable like gender or educational attainment, the current study streamlines the data collection and analysis process. As a result, all of the restrictions listed here will provide clear directions for further study.

As a result, future researchers might carry out their research by covering up the intention of digital entrepreneurs in various nations to use BCT. The social influence, family support, and effort expectancy could all be taken into account by the researchers to forecast the digital entrepreneurs' propensity to use BCT. In addition, future researchers may consider controlling variables like gender or educational attainment to create more thorough studies in this field. Future research must also highlight other necessary viewpoints in addition to digital entrepreneurs' intent to use BCT, such as government action, social consciousness, the state of the economy, and technological infrastructure to forecast the chance to meet UN SDGs.

Ethical statement

Research Ethics Committee of Social Science Association, Bangladesh (FBS-EAR-2023-021) gave its approval for this study. All participants provided written informed consent.

Funding statement

This innovative work has not received funding from any public or private entities. Not even the author's employers has provided funding for this mixed-method study.

Data availability statement

Data will be made available on request.

CRediT authorship contribution statement

Md. Rabiul Awal: Supervision, Software, Resources, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Md. Solaiman Chowdhury:** Writing – review & editing, Writing – original draft, Visualization, Validation.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper. Regarding the data collection, analysis, or any other significant task of the paper's drafting and finalization, the authors will not be held responsible to any other party.

Acknowledgement

The researchers of this paper appreciate and owe to the experts who assisted with the pilot testing and the respondents who took the time to fill out the questionnaire survey.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.heliyon.2024.e33853.

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