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Original Article

Unveiling the Components Driving Green Technology Development in Electronic Education: A Mixed-Methods Approach with Blockchain Integration

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Abstract

This study investigates the crucial components propelling the integration of green technology and blockchain technology within electronic education (e-learning). Employing a mixed-methods research design, the inquiry blends quantitative and qualitative methodologies for comprehensive analysis. The qualitative phase draws upon the expertise of 125 purposefully sampled academic experts, subject-area specialists, and e-learning professionals through semi-structured interviews. Content analysis dissects these qualitative data, while structural equation modeling and factor analysis illuminate the quantitative dimension. The findings unveil five key components orchestrating green technology development in e-learning with blockchain integration: causal conditions, central phenomena, strategies, background conditions, and intervening conditions. Further analysis within each component identifies critical sub-components, informed by expert insights. Collectively, the study's predictor variables, encompassing both green technology development components and blockchain technology utilization, demonstrate a significant predictive influence (0.36, $p < 0.01$) on the mediator variable, green technology development. Additionally, they exhibit a nuanced yet statistically significant predictive effect (0.16, $p > 0.05$) on the criterion variable, e-learning and educational software performance enhancement. These positive and direct associations suggest a robust model for integrating blockchain technology to propel green technology advancements within e-learning. The proposed five-component model sheds light on the interplay between key factors, emphasizing the substantial impact of its application in guiding effective integration strategies.

Keywords

Electronic education, green technology, blockchain technology, mixed-methods research, component analysis, model development.

Introduction

In One of the strategies of modern educational systems worldwide is relying on information and communication technology. With the help of these tools, systems and virtual networks have been developed for educating learners. Green technology systems in education are among the recent approaches that, alongside the significant growth in their utilization in educational systems, have gained high popularity among learners of educational courses. The efficiency of these systems is notable due to their ability for unlimited development in educational regions, accessibility, usability, lack of need for facilities and equipment compared to traditional education methods, as well as their capability to transfer and store information, securing a special position in the world of education.

Green technology in education involves planned learning where learning and teaching usually take place in separate environments. Therefore, green technology in education relies on communication and institutional technologies for design and planning. Distance learning only focuses on the learner's needs for interaction with the instructor, while this type of education should involve both parties, namely the instructor and the learner (Andoni, 2021).

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Meanwhile, blockchain technology is a management tool that allows learners in e-learning to precisely determine the diversion of information security and cloud space between the program and actions performed in e-learning, in the event of a network intrusion or interference. A key advantage of blockchain technology is its role as an early warning system against security threats, information, and delays in the cloud space (Berger, 2022). In other words, blockchain technology can be considered a network that functions like a database but has no specific centralization and is not controlled by any institution or organization. The information stored in the blockchain is different from the information stored in databases. The information in the blockchain is stored inside blocks, each of which, in addition to the information it contains, has a "hash." Hash is a set of characters created using specific algorithms. Each block, based on the information it contains, has its own corresponding hash, which symbolizes the information within that block. Even if a very small part of the information is changed or deleted, the hash changes entirely (Dubrovnik, 2021).

The information stored in blockchain can be anything and is not summarized only in transactions. Each block, in addition to the information stored within it, has a "hash." Hash is a collection of characters created using specific algorithms. Each block has its own hash based on the information it contains, and this hash somehow symbolizes the information within that block. Even if a very small part of the information is changed or deleted, the hash changes entirely (Houshmand et al., 2022). Elisan (2021), in their report titled "Blockchain: A New Opportunity for Providers and Consumers of Educational Systems and Software," studied various applications of blockchain in the education systems and software sector. The results of this report indicate that blockchain can address some challenges faced by organizations active in the field of educational systems and software. Hakius (2022), in a report titled "Blockchain in the Development of Educational Network Security: A Study Based on Decision Makers' Opinions and the Development of the Technological Infrastructure in Germany," conducted research on the implementation of blockchain in the development of network security in educational settings. According to the results of this study, over 50% of the participating organizations have ideas and plans regarding the operationalization of blockchain in the development of network security in education. Harry (2022), in a research paper titled "Blockchain: A Secure, Decentralized, and Trustworthy Framework for Educational Network Security," explored various aspects of the applications of blockchain technology as a secure, distributed, and trustworthy framework for future networks of educational systems and software.

This type of technology possesses key indicators such as decentralization, stability, anonymity, and responsiveness. It can operate in a decentralized environment by integrating multiple core technologies such as hash encryption, digital signatures, and distributed consensus mechanisms (Lakampal, 2021). In the context of e-learning performance, blockchain can enhance essential services related to securing information (Manmaru et al., 2022).Blockchain technology creates an acceptable and decentralized dataset for exchanging information (Sabunchi et al., 2022). This dataset continuously updates learning and teaching information, current users, future users, data transfer fluctuations, and innovations. It reports organizational information collaboratively to other organizations, intermediaries, networks, and international educational and research gateways (Tama, 2020). These areas form a cohesive network of layers or information blocks where information is allocated to each block in the form of hashes. These blocks are connected to the nodes of other organizations and data gateways, forming a large, up-to-date global information network.

In other words, an educational organization (A) can enter information related to its educational services into the blockchain network with existing innovations and quantitative and qualitative characteristics, and nodes facilitate the transfer of entered information to blocks of information (L2...Ln) in other points for organizations (B) or intermediaries (C) or networks (D), creating a foundation for the development of green technology (Tanaka, 2022). As a core application in the smart network, blockchain can provide a solution for creating educational and research infrastructure in a smart network (Hansen et al., 2021). Ideally, the use of blockchain allows parties in a smart network, including consumers and users, to establish communication without relying on third-party trust. The use of blockchain-based educational and research infrastructure in a smart network promises various advantages (Zhu et al., 2021).

According to the "Global E-Learning Data Exchange Review" (2022), the annual total exchange of e-learning information was $34.5 billion (citing McDaniel, 2021). This report also conducted statistics and analysis based on the volume of upstream, midstream, and downstream information exchange. Due to the vast and complex nature of the e-learning sector, long and complex contracts may be concluded for information security by all parties involved, and the number of contracts may be significant. Smart contracts can significantly reduce paperwork, simplify workflow, improve efficiency, and save costs (Nikforov, 2022).

In the exchange of e-learning information, traditional methods can lead to inevitable errors in information exchange and make the information exchange susceptible to fraud and compromise. Blockchain technology can effectively address this issue and make information exchange more transparent. Both parties in the information exchange can view all records of information exchange and assessments of the other party, thereby improving the success rate of information exchange. Additionally, both parties in information exchange can also see the status of each stage of the information exchange process to control the overall situation (Holin, 2021).Blockchain technology can revolutionize the education sector at the green technology development level by overcoming various challenges such as data transfer fluctuations, supply chain, accounting, data management, and security. It can also assist in simplifying various engineering and technical decisions. Technologically, the education sector has been highly innovative, introducing new formulas and processes to enhance the quality of educational services in the face of competition. Blockchain can contribute to making these traditional methods more efficient (Hansen & Liu, 2021). Therefore, this study has been conducted with the aim of identifying the key components of green technology development in e-learning using blockchain technology.

Research Methodology

The research strategy employed in this study is a mixed-methods approach, combining both quantitative and qualitative methods. The research method is qualitative, utilizing a foundational data theory, and the data collection method is semi-structured interviews. The population for the qualitative segment includes experts and stakeholders in the academic field related to the research domain, as well as experts and managers in the field of education. Through purposeful or snowball sampling, the sample size reached theoretical saturation, and a total of 15 individuals were interviewed.

In the quantitative part of the research, the population includes all managers and specialists in educational organizations. The total number is 258, and 125 individuals were selected through accessible and purposive sampling methods.

The research process involves the development of a research plan, preliminary review of theoretical foundations in the blockchain technology and green technology development domain, and clarification of key concepts necessary for designing and explaining the native model of blockchain technology in green technology development. This section encompasses the identification and explanation of the research design, including the preparation of the research plan, preliminary review of theoretical foundations in the field of blockchain technology, and clarification of key concepts. The native model of blockchain technology in green technology development is also discussed. In the subsequent phase, considering the findings of the first part, interview scripts were developed. Deep interviews were conducted with managers and professors, accompanied by a thorough review of the literature on the research topic to extract data for qualitative analysis and the presentation of the initial model. The interviews continued until reaching saturation, and then, using a qualitative approach, various aspects of the blockchain technology model in green technology development, including causal conditions, contextual conditions, intervening conditions, central phenomenon, and strategies and consequences, were addressed. To explain the research model, the paradigm model of Strauss and Corbin was utilized, employing a foundational data strategy. In the next step, correlation research was used to determine the relationships between the model variables. For quantitative data analysis and model fitting, SPSS22 and Smart PLS software were utilized.

Figure 1. Conceptual Map of Research Stages

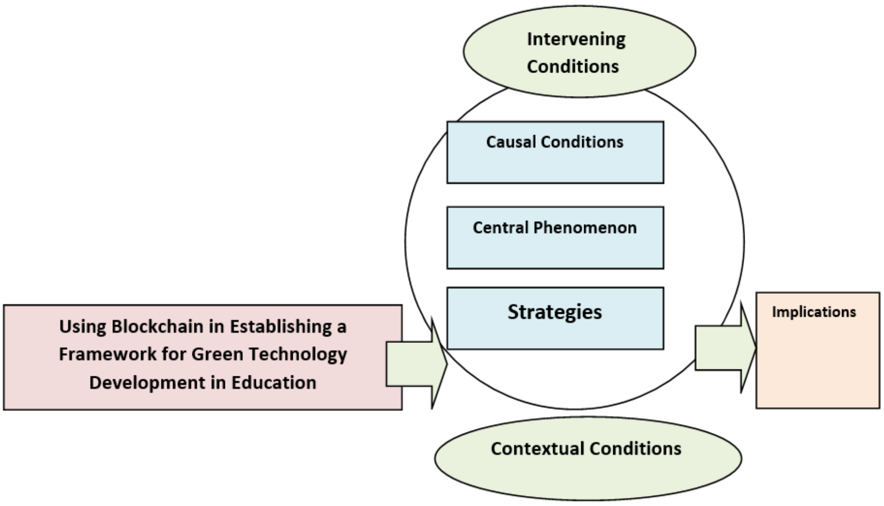


Figure 2. Conceptual Model of the Research

Research Findings

A) Qualitative Section Evaluation

The aim of this research is to identify the components of green technology development in education using blockchain technology. In this regard, the first step was to review the textual evidence of the research and identify concepts. The process of open coding was then performed, and the components of the coding paradigm, including Ali conditions, main phenomenon, strategies, context, intervention conditions, and consequences, were identified and presented based on their sub-categories. Initially, in the open coding, the data were broken down into separate sections to carefully examine similarities and differences. Questions about the phenomena indicated by the data were raised. Open coding is a part of the analysis that specifically involves naming (conceptualization) and categorizing the phenomena by closely examining the data. Therefore, it can be said that two main actions take place in open coding, namely conceptualization and categorization. The sub-concepts and categories of this research are presented in Table (1).

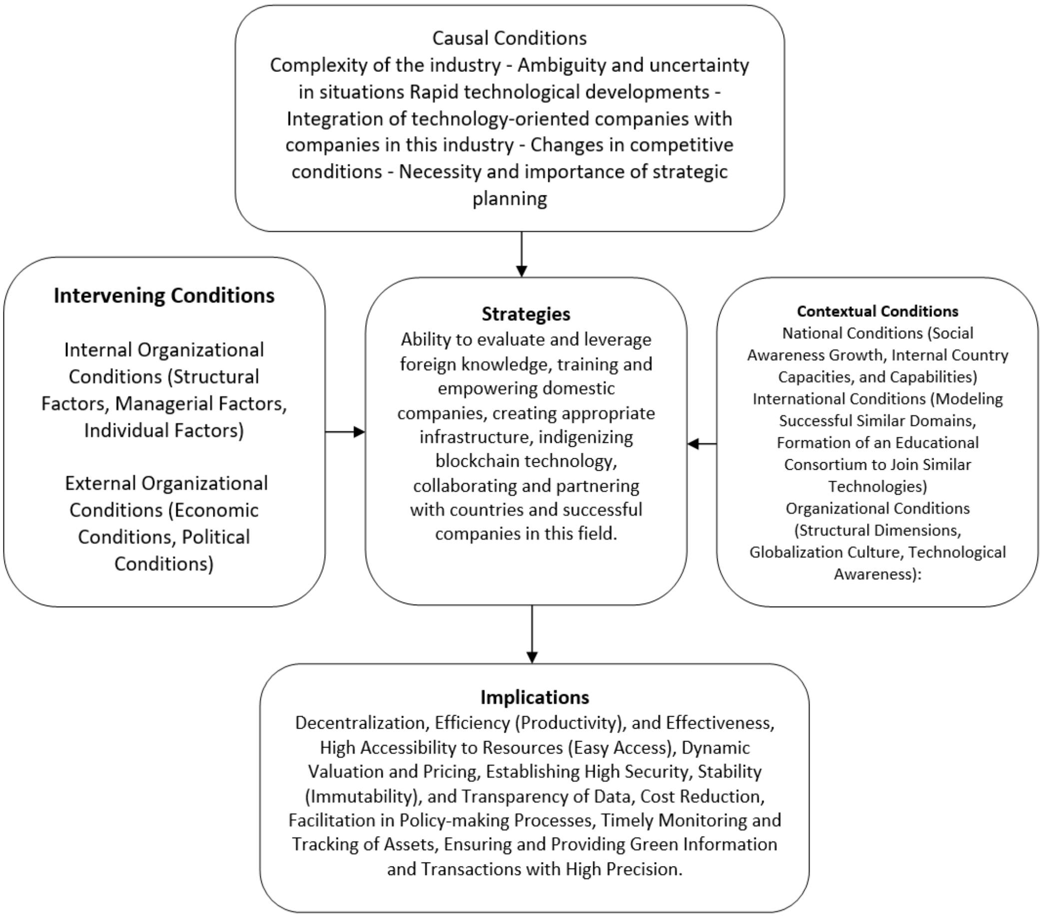


Figure 3. Encoding Axis Based on the Paradigmatic Research Pattern

Selective encoding is a process of harmonization and improvement. This process connects concepts by drafting a narrative path. Referring to Figure (5), the model of using blockchain technology in the development of green technology can be interpreted as follows: organizations active in the field of e-learning and education, aiming for survival and maintaining competitiveness, increasing efficiency, making better decisions, and risk management. Ultimately, striving for excellence in conditions where technologies rapidly change, e-learning becomes more complex, and competition dynamics shift between internal and international organizations. Given the strategic importance of this sector and its role in educational software systems, each country and society's need for this domain, organizations need to be prepared for the future. This readiness is manifested through the presence and utilization of blockchain technology.

Table 1. Causal Conditions

Main category	Subcategory	Concepts
Causal Conditions	Complexity in creating a green technology development platform	Multiple stakeholders in creating a green technology development platform Broad dimensions in creating a green technology development platform Ambiguity in changes in creating a green technology development platform Uncertainties in creating a green technology development platform
	Rapid technological developments	Technological changes The speed of innovation The speed of science production
	Changing conditions of competition	National and international competition Entry of new competitors Changing the educational model
	The Necessity and Importance of Strategic Planning	Impact on other processes and raw materials of other sectors Strategic importance of creating a platform for the development of green technology Public and political importance Educational importance Dependency of the country on this field
	Ambiguity and uncertainty in situations	Complexity in the sector in the future National concern about the future Unpredictability of future conditions High ambiguity in international balance
	Integration of technology-focused organizations with other entities in creating a platform for the development of green technology.	The presence of new organizations in this sector with different expertise, the existence of large financial flows and attractiveness for the entry of technological organizations, the need to use new technologies and specialized organizations in this field for all processes of the education sector.

Table 2. Central Phenomenon (Using Blockchain in the Education)

Main category	Subcategory	Concepts
Central Phenomenon (Using Blockchain in the Education)	Network exploration	Monitoring user needs Continuous communication with users Demand analysis
	Monitoring competitors	Understanding competitors' concepts Monitoring competitors Examining and analyzing their reactions
	Sector exploration	Monitoring major trends and developments at the national, regional, and international levels (production of new educational services, various types of new discovery methods, various new mechanisms). Monitoring sector changes at the national, regional, and international levels; monitoring the latest technologies and innovations in the sector. Identifying change-causing factors. Identifying key players.
	Organizational exploration	Identifying organizational strengths and weaknesses Identifying threats and opportunities
	Monitoring documents and regulations	Concepts of examining upper-level organization documents Examining national documents Reviewing national and international laws and standards in the field of e-learning and education.
	Creating an intelligent information system	Establishing a database derived from information Creating evaluation systems
	Sector transactions and exchanges	Financial transactions Interaction with the supply chain Exchange of information among internal subsidiaries Communication with potential new users Collaboration with other organizations and forming an educational consortium Exchange of educational services

Afterwards, the interviewees were asked to express the actions that need to be taken for the implementation and execution of blockchain for use in the e-learning sector. In the coding phase, five (5) effective strategies were identified: assessing and utilizing external knowledge, training and empowering internal organizations, creating appropriate infrastructure, localizing blockchain technology, and collaborating and partnering with successful countries and organizations in this field.

Table 3. Strategies

Main category	Subcategory	Concepts
Strategies	The ability to evaluate and apply foreign knowledge	Learning ability Ability to exchange knowledge and experiences Pattern recognition from successful organizations"
	"Establishment of appropriate infrastructure"	"Employment and attraction of specialized human resources Procurement and availability of hardware compatible with modern technology Development of software and mastery of them Identification and clarification of new and important cryptocurrency codes Mastery of general regulations of cryptocurrencies"
	"Localization of Blockchain Technology"	"Creation and development of national cryptocurrencies Development of national blockchain networks for domestic transactions Training and learning for sector organizations in the blockchain domain Drafting and establishing national regulations for blockchain and cryptocurrencies"
	"Collaboration and partnership with successful countries and organizations in this field"	"Formation of consortia with successful organizations in this field Utilization and integration with knowledge-based organizations in this field"
	"Training and Empowerment of Internal Organizations"	"Planning specialized sessions and conferences Organizing conferences and workshops Conducting educational and specialized courses"

In this section, based on the opinions of research experts, the determination and weighting of the criteria of the main research model have been carried out. Structural, managerial, individual, and educational-political variables, along with their sub-components, have been identified and weighted.

Step 5-1- First Step: Determining the Weights of Aspects, Strategies, and Key Factors

Table 4. The weights of structural, managerial, individual, and educational-political variables

Final Weight	Criteria Weight	Level Weight	Abbreviation	Title
۰,۱۱۵	۰,۳۸٦	۰,۷۵٦	A1	Section Complexity
۰,۱۰۲	۰,۲۵۱	۰,۷٤٤	A2	"Ambiguity and Uncertainty in Situations"
۰,۰۹۹	۰,۲۵۵	۰,۷۲۵	A3	Rapid technological developments
۰,۰۸۱	۰,۲۹۸	۰,٦۸۷	A4	"Integration of Technology-Centric Organizations with Others in Creating a Green Technology Development Platform"
۰,۰۷٤	۰,۲٦۱	۰,٦۳۹	A5	Competitive Landscape Change
۰,۰۸۷	۰,۱٤٦	۰,۵۷۹	A7	Network Exploration

٠,٠٧١	٠,١٣٢	٠,٥١١	A9	Section Exploration
٠,٠٢٦	٠,٠٩٨	٠,٤٩٤	A10	Document Monitoring
٠,٠٥٥	٠,٠٦٩	٠,٤٨١	A11	Organizational Exploration
٠,٠٣٦	٠,٠٥٥	٠,٤٦٩	A12	Section Exchanges
٠,١٦٢	٠,٤٦٣	٠,٥٩٣	M1	Smart System Development
٠,٠٩٩	٠,٠٨٤	٠,٥١٦	M3	Decision Improvement
٠,٠٩٢	٠,١٢٦	٠,٤٨٧	M4	Localization
٠,٠٨٤	٠,٠٩٤	٠,٤٥٢	M5	Collaborative Partnership
٠,٠٧٠	٠,١١٤	٠,٤٤٠	M6	Training
٠,٠٦١	٠,١٥٨	٠,٤١٦	M7	International Conditions
٠,٠٥٨	٠,١١٥	٠,٣٩٤	M8	National Conditions
٠,٠٥٥	٠,٠٩٥	٠,٣٧٥	M9	Micro-Organizational Conditions
٠,٠٤٩	٠,٠٨١	٠,٣٤٢	M10	Structure
٠,٠٤٥	٠,١٣٦	٠,٣٢٧	M11	Management
٠,٠٣٩	٠,١٧٩	٠,٣٠٨	M12	Individual Factors
٠,٠٣٧	٠,٠٩١	٠,٢٨٧	M13	Educational Factors
٠,٢٢٦	٠,٥٣٢	٠,٦١٢	V1	Political Factors
٠,٢٠٢	٠,٢٨٢	٠,٥٩٢	V2	Intelligence
٠,١٨٧	٠,٢٤٤	٠,٥٧٣	V3	Intelligence
٠,١٥١	٠,٣٦٥	٠,٥٤١	V4	Access
٠,١٣٢	٠,٠٨٨	٠,٥٢٧	V5	Tracking
٠,١١٥	٠,١٨٩	٠,٤٧٩	V6	Decision Improvement
٠,٠٩٧	٠,١٢٧	٠,٤٢٥	V7	Security
٠,٠٨٣	٠,٠٩٧	٠,٣٧٧	V8	Information Transfer
٠,٠٧٦	٠,٠٨٩	٠,٣٤٢	V9	Information Transfer
٠,٠٥٢	٠,١٣٥	٠,٣١٨	V10	Information Transfer

Step 5-2: Determining the Importance of Each Plan using the Requirements Expansion Method
Since the development plans under consideration within the framework of the blockchain technology utilization model in educational information security do not all share the same priority, and considering that multiple development plans can be proposed for each goal in the model, the Requirements Expansion method has been employed to specify the priority and weight of each development plan. To compare the plans (HOWs) and objectives (WHATs), a cognitive language scale has been utilized for qualitative assessment. The scales and the pattern of blockchain technology utilization in educational information security related to each scale are presented in Table 5.

Table 5. The Process of Blockchain Technology Utilization Model in Educational Information Security Based on Requirements Elaboration

Symbol associated with each language scale.	Language Scales	The Blockchain Technology Utilization Model in Educational Information Security Based on Requirements Elaboration
VL	Very Low	(٠و١و٢)
L	Low	(٢و٣و٤)
M	Moderate	(٤و٥و٦)
H	High	(٦و٧و٨)
VH	Very High	(٨و٩و١٠)

In this research, to determine the importance of each goal (WHATs) and the relationship between goals and plans, the opinions of three Requirements Elaboration managers were collected, and the averages of these opinions were calculated. Symbols were defined for each opinion. In Table

(6), symbols and the average opinions of three categories of the sample population (1- managerial staff, 2- academic elites, and 3- operational staff) explaining the requirements are presented. These symbols have been used to determine the relationship between goals and plans and the importance of goals in the pattern of using blockchain technology in educational information security.

5-2-1 -Symbols and Average Opinions - Structural Variables

Table 6. The Level of Importance of Structural, Managerial, Individual, and Educational Political Variables

DM1: Management Staff DM2: Academic Elites DM3: Operational Staff	DM1: Management Staff DM2: Academic Elites DM3: Operational Staff	DM1: Management Staff DM2: Academic Elites DM3: Operational Staff	Abbreviation	Title
VH	VH	H	A1	Section Complexity
VH	M	VH	A2	"Ambiguity and Uncertainty in Situations"
H	VH	H	A3	Rapid technological developments
L	M	M	A4	"Integration of Technology-Centric Organizations with Others in Creating a Green Technology Development Platform"
H	VH	H	A5	Competitive Landscape Change
L	M	H	A7	Network Exploration
H	M	H	A9	Section Exploration
VH	M	H	A10	Document Monitoring
M	M	H	A11	Organizational Exploration
M	L	L	A12	Section Exchanges
M	VH	H	M1	Smart System Development
VH	VH	M	M3	Decision Improvement
VH	H	VH	M4	Localization
VH	VH	VH	M5	Collaborative Partnership
H	H	H	M6	Training
L	M	M	M7	International Conditions
M	M	M	M8	National Conditions
M	H	H	M9	Micro-Organizational Conditions
L	M	L	M10	Structure
L	M	L	M11	Management
VL	VL	M	M12	Individual Factors
VL	L	M	M13	Educational Factors
VH	VH	VH	V1	Political Factors
H	VH	H	V2	Intelligence
VH	H	H	V3	Intelligence
H	VH	H	V4	Access
H	M	H	V5	Tracking
VH	VH	H	V6	Decision Improvement
H	H	H	V7	Security
H	VH	VH	V8	Information Transfer
H	H	M	V9	Information Transfer
M	H	M	V10	Information Transfer

For example, to determine the importance of goals (WHATs) in the table of the pattern of using blockchain technology in educational information security, collected opinions were averaged. The results are presented in Table (7).

Table 7. Opinion Results

	Section Complexity	Cost Reduction	Rapid Technological Transformations	Changes in Competitive Conditions	Strategic Necessity and Importance	Ambiguity and Uncertainty in Situations	Integration of Technology-Centric Organizations with Organizations in this Section	Competitor Monitoring	Section Exploration	Organizational Exploration	Monitoring Documents and Regulations	Establishing an Intelligent Information System	Interactions and Section Exchanges
DM1	H	VH	M	VH	H	M	H	M	H	M	VH	M	L
DM2	VH	VH	VH	H	M	H	H	M	VH	M	H	M	M
DM3	H	VH	VH	M	H	H	H	M	VH	M	H	M	L
وزن هر یك از WHATs	(6.67,7.67,8.67)	(8,9,10)	(6.67,7.67,8.67)	(6,7,8)	(5.33,6.33,7.33)	(5.33,6.33,7.33)	(6,7,8)	(4,5,6)	(7.33,8.33,9.33)	(4,5,6)	(6.67,7.67,8.67)	(4,5,6)	(2.67,3.67,4.67)
نماد	A1	A2	V1	M1	H!	A3	V2	M2	M3	A4	H1	M4	V3

Finally, the relative importance of each development plan from the pattern of using blockchain technology in educational information security has been determined for use in subsequent stages. The matrix of the pattern of using blockchain technology in educational information security, along with calculations in Table (8), is presented. To facilitate better comparison and ranking of values, the weighted values obtained from the table of the pattern of using blockchain technology in educational information security have been assigned weights. The plan with the highest net value should be given priority. If M (a, b, c) is an ordinal number, the unclassified value can be calculated using the Yager method as follows:

$$\frac{L+2M+U}{4}$$

Table 8. Matrix of the Pattern of Using Blockchain Technology in Educational Information Security

HOWs **Plans** / **Objectives** WHATs	**Structural Factors**	**Management Requirements for Logistics Services in Production**	**Individual Factors**	**Political Educational Conditions**	**WHATs**
Section Complexity	A7	A5		A4	A1
Cost Reduction	A10	A7		A4	A2
Rapid Technological Transformations	A2	A1	A7	A3	V1
Changes in Competitive Conditions	A3		A10	A4	M1
New Users			A4	A5	H!
Ambiguity and Uncertainty in Situations	A3		A8		A3
Added Value	A4			A3	V2
Development of Educational Services	A5				M2
Section Exploration	A2	A3		A10	M3
Organizational Exploration		A2			A4
Monitoring Documents and Regulations	A4	A3		A10	H1
Establishing an Intelligent Information System		A2			M4
Section Interactions and Exchanges		A11			V3
Importance of each plan	(۱۹۶,۳،۲۵۲,۶۳،۳۱۹,۹۶)	(۱۵۷,۷۱،۲٤٦,۹۱،۳۵۵,۰۳)	(۱۲۵,۷۵،۱۷٤,٤،۲۳۱,۰٦)	(۲۰۰,۸۷،۲۹٦,٥٤،۳۹۸,۲۱)	
Assigned weights for each value	۲۵۵,۳۸	۲۵۱,٦٤	۱۷٦,٤	۲۹٥,٥٤	
Normalized (W)	۰,۱۱۳۵	۰,۱۱۱۸	۰,۰۷۸٤	۰,۱۳۱٤	

5-3-Step Three - Selection of Implementable Development Plans Using the Blockchain Technology Pattern in Educational Information Security

When selecting a development plan, reliance cannot be placed solely on one goal. In fact, models that have addressed this issue using mathematical programming techniques have been optimizing based on multiple objectives. One of these techniques is goal programming, which is a more suitable method for simultaneously addressing multiple objectives. Goal programming is designed to solve problems with multiple conflicting goals. Additionally, for research constraints, zero-one goal programming is a very useful tool for finding optimal solutions. At this stage, all computational data obtained for formulating the zero-one goal programming model to determine the category of development plans that should be prioritized in the organization's performance improvement process have been integrated. Considering the multiple goals and constraints in this research, the implementable development plans are selected using zero-one goal programming. The objective of the goal programming model is to choose plans with the lowest implementation cost, the highest ease of execution, and the highest relative importance (the final result of the quality house table). The ease of execution for each plan is determined on a five-point spectrum from very high to very low. To use the goals (normalized values from the quality house matrix and the ease of execution for each plan) desired in the model of the pattern of using blockchain technology in educational information security, they need to be normalized. The results of normalizing the goals and the actual budget constraint value are shown in Table (9). The formula for the goal programming model used in this article is as follows, taken from the model presented by Gayer and Leung in 2001 and Carsak et al. in 2002. The constructed model was solved using WinQSB software, and the results are presented in Table (10)

Table 9. Real Values (Plan Scores) and Normalized (Ease of Execution and W) Values for Each Plan

	۱	۲	۳	۴	۵	۶	۷	۸	۹	۱۰	۱۱	۱۲	۱۳
Normalized	۰٫۰۲۵۷	۰٫۱۱۳۵	۰٫۱۱۱۸	۰٫۰۷۸۴	۰٫۱۳۱۴	۰٫۰۵۸۴	۰٫۱۳۸۳	۰٫۰۷۵	۰٫۰۷۷	۰٫۰۳۶۱	۰٫۰۴۶۶	۰٫۰۳۰۴	۰٫۰۷۶۹
Plan Scores	۶٫۵	۷٫۵	۲۵	۱۱	۲۱	۱۰	۹	۴٫۶	۴	۴	۷	۱۰	۴٫۲
Ease of Execution	۰٫۰۶۸	۰٫۰۹	۰٫۰۲۲	۰٫۰۴۵	۰٫۰۹	۰٫۰۶۸	۰٫۰۴۵	۰٫۱۱۳	۰٫۰۹	۰٫۱۱۳	۰٫۱۱۳	۰٫۰۶۸۶	۰٫۰۶۸

Min Z=0.708d-1+(0.211/75) d+2+0.081d-3
S.T:
0.0257x1+0.1135x2+0.1118x3+0.0784x4+0.1314x5+0.0584x6+0.1383x7+0.075x8+0.077x9+0.0368x10+0.0466x11+0.0304x12+0.0769x13+d+1-d-1=1
6.5x1+7.5x2+25x3+11x4+21x5+10x6+9x7+4.6x8+4x9+4x10+7x11+10x12+4.2x13 + d+2-d-2=75
0.068x1+0.09x2+0.022x3+0.045x4+0.09x5+0.068x6+0.045x7+0.113x8+0.09x9+0.113x10+.113x11+0.068x12+0.068x13+d+3-d-3=1
xjε{0,1} , j=1,....,13 , d-i , d+i≥0 , i=1,2,3

6. Discussion

To achieve this, the model ranks the implementation feasibility of executable plans. The results of solving the models of the pattern of using blockchain technology in the security of education information and expanding the functionality of requirements are shown in Table (10).

The results of the pattern of using blockchain technology in the security of education information

Table 10. Results of the Pattern of Using Blockchain Technology in the Security of Education Information

Development Plans	Structural Factors	Requirements for Logistic Services Production Management	Individual Factors	Educational-Political Conditions
Rank	1	3	2	4
Pattern of Using Blockchain Technology in the Security of Education Information	Accept (1)	Accept (1)	Accept (1)	Accept (1)

Based on the normalized weight estimation, the score of the plan, and the ease of implementation in the step of selecting executable development plans using the pattern of using blockchain technology in the security of education information, four main research factors were considered: 1- Structural Factors, 2- Requirements for Logistic Services Production Management, 3- Individual Factors, and 4- Educational-Political Conditions. Also, the performance evaluation system component was examined during the research to assess the performance levels of each of the following four steps: Step 1: Formation of the pattern of using blockchain technology in the security of education information and the development of plans. Step 2: Determining the weights of aspects, strategies, and key factors. Step 3: Assessing the importance of each plan using the expansion of the functionality of requirements method. Step 4: Selecting executable development plans using the pattern of using blockchain technology in the security of education information and training. The results showed that in all examined items (13 items for the first three perspectives and 7 items for the fourth perspective), only structural factors and individual factors had appropriate normalized weights, plan scores, and ease of implementation, obtaining the first and second ranks. The two factors of logistic services production management requirements and educational-political conditions, with lower normalized weights, plan scores, and ease of implementation, are less utilized in formulating the main requirements, and their components are less used.

7- Executive action plans based on the pattern of using blockchain technology in the security of education information

Table 11. Executive action plans based on the pattern of using blockchain technology in the security of education information

Deputy of Education and Research	**Technical Production and Treatment Centers Section**	**Executive Action Plans:**	
Deputy of Medical Staff and Logistics Service Management Requirements Development of Human Capital	Communication Section with Management Factors	Complexity Section	Q1
Deputy of Finance	Financial Affairs	Ambiguity and Uncertainty in Situations	Q2
Deputy of Medical Staff and Logistics Service Management Requirements Development of Human Capital	Communication Section with Management Factors	Integration of Technology-Oriented Organizations with Organizations in Creating a Green Technology Development Platform	Q3

All Organizations	Managers and Technical Experts	Decision Improvement	Q4
Management	Managers and Technical Experts	Creation of Intelligent Systems	Q5
Management	Managers and Technical Experts	Management Information and Decision Support Systems	Q6
Management	Medical Staff	Evaluation	Q7
All Organizations	Managers	Political Factors	Q8
Deputy of Education and Research	Managers		Q9
Deputy of Education and Research	Managers	Intelligence	Q10
Deputy of Education and Research	Human Resources Section	Efficiency	Q11
Organizational Affairs Deputy	Technical Production and Treatment Centers Section		Q12
Deputy of Education and Research	Technical Production and Treatment Centers Section	Educational Factors	Q13

In examining the executive action plans based on the pattern of using blockchain technology in the security of education information, we have made the final selection of 13 items (Q) or the strategy of requirements (among the initial components: 13 structural, managerial, individual, political-educational, 13 logistic services production management requirements, 14 internal process, and 7 perspectives on educational-political conditions). This selection was based on the results of the model using blockchain technology in education information security, which was carried out based on the normalized weight estimation, plan score, and ease of implementation. It was shown that considering the high importance of two factors: structural and individual, a total of 9 items (Q) or final requirements were extracted from these two categories, and four other requirements (Q) were less considered in the formulation of logistic services production management requirements and political-educational conditions due to lower levels of normalized weight coefficients, plan scores, and ease of implementation.

For each of the executive action plans or (Qs), a responsible unit and related affairs were selected.

The most important requirements or executive action plans included:

1. Focus on Complexity Section
2. Focus on Ambiguity
3. Focus on Integration
4. Focus on Decision Improvement
5. Focus on Creating Intelligent Systems
6. Focus on Management Information and Decision Support Systems

8. Finalizing the Requirements in the Final Stage

Table 12. Documentation-based Final Requirements

Related Programs and Executive Actions	Key Factors	
Q1, Q2, Q3, Q5, Q6, Q9, Q11	Strategies for Increasing Profit and Revenue	Structural Factors
Q5, Q2, Q4, Q8, Q9, Q10, Q11,Q13	Increasing and Deepening Relationships with Logistic Services Production Management Requirements Development of Human Capital	Requirements for Logistic Services Production Management
Q7, Q8, Q9, Q2, Q4, Q12	Network Segmentation in Line with Production Type and Demands	Individual Factors

In proportion to each step, providing or allocating requirements or executive action plans for each step has been addressed. For example, in the step of political-educational conditions, 5 requirements have been developed for the use of blockchain technology in securing education information.

9- Fuzzy Data Processing

In this stage, to examine the level of agreement among the opinions of the questionnaire respondents regarding each component of the model for using blockchain technology in the development of green technology in education, the ICC coefficient has been calculated for each factor of the pattern. Then, to calculate the weights of the indices of the model for using blockchain technology in the development of green technology in education, the weights of the main factors explained were determined between 1 (W1) and 4 (W4) based on expert opinions. These weights were determined as 0.35, 0.40, 0.10, and 0.15, respectively. The results are shown in the table, and based on this index, the set of factors can be preliminarily ranked.

Table 13. Calculation of the Initial Index of Using Blockchain Technology in the Development of Green Technology in Education

	P	**I۱**	**I۲**	**I۳**	**I۴**	**PIR**
Complexity Section	۰,۸۸۳	۷,۶۶۷	۹,۰۰۰	۳,۰۰۰	۱,۰۰۰	۶,۰۹۰
Cost Reduction	۰,۱۳۳	۸,۶۶۷	۷,۸۳۳	۱,۸۳۳	۰,۸۳۳	۰,۸۸۲
Rapid Technological Transformations	۰,۹۶۷	۸,۱۶۷	۱۰,۰۰۰	۷,۶۶۷	۴,۳۳۳	۸,۱۸۲
Changes in Competitive Conditions	۰,۷۰۰	۳,۰۰۰	۹,۰۰۰	۸,۵۰۰	۲,۳۳۳	۴,۲۷۸
New Users	۰,۲۳۳	۱,۶۶۷	۴,۶۶۷	۰,۳۳۳	۰,۶۶۷	۰,۵۹۸
Ambiguity and Uncertainty in Situations	۰,۰۱۷	۸,۵۰۰	۶,۶۶۷	۹,۳۳۳	۰,۵۰۰	۰,۱۲۰
Added Value	۰,۹۳۳	۸,۵۰۰	۹,۳۳۳	۷,۶۶۷	۴,۶۶۷	۷,۷۹۶
Development of Educational Services	۰,۹۳۳	۶,۶۶۷	۹,۱۶۷	۴,۶۶۷	۸,۰۰۰	۶,۹۸۲
Sector Exploration	۰,۹۰۰	۷,۶۶۷	۸,۱۶۷	۹,۰۰۰	۱,۳۳۳	۶,۷۳۰
Organizational Exploration	۰,۶۳۳	۷,۰۰۰	۷,۸۳۳	۷,۳۳۳	۱,۵۰۰	۴,۳۵۲
Monitoring Documents and Regulations	۰,۶۶۷	۶,۳۳۳	۸,۰۰۰	۷,۰۰۰	۱,۳۳۳	۴,۴۱۹
Establishment of an Intelligent Information System	۰,۷۶۷	۹,۰۰۰	۸,۳۳۳	۶,۳۳۳	۱,۱۶۷	۵,۸۴۶
Section Transactions and Exchanges	۰,۸۵۰	۶,۰۰۰	۸,۰۰۰	۴,۳۳۳	۱,۸۳۳	۵,۲۳۷

Table 14. Decision Matrix in the Model of Using Blockchain Technology in the Development of Green Technology in Education

	PIR	**$SIR_{۱}$**	**$SIR_{۲}$**	**$SIR_{۳}$**	**$SIR_{۴}$**	**$SIR_{۵}$**	**$SIR_{۶}$**	**$SIR_{۷}$**	**$SIR_{۸}$**	***$SIR_{۹}$***
Complexity Section	٦/٠٩	٥٠/٨	٦٧/٦	٥٠/١	٦٧/٨	٥/٠٠	٦٧/٠	٣٣/٨	٦٧/٧	٨٣/٠
Cost Reduction	٨٨/٠	٥٠/٩	٥٠/٩	١/٠٠	٠/٠٠	٥٠/٠	٣٣/٧	٣٣/٩	٦٧/٩	٣٣/٥
Rapid Technological Transformations	١٨/٨	٣٣/٩	٥٠/٩	٦٧/٠	٨٣/٩	٣٣/٩	٠/٠٠	٨/٠٠	٨٣/٨	٨٣/٠
Changes in Competitive Conditions	٢٨/٤	٦٧/٤	٥/٠٠	٦٧/٦	٥/٠٠	٩/٠٠	١٧/٨	٣٣/٩	٣٣/٨	٣/٠٠
New Users	٠/٦٠	٣٣/٣	١/٠٠	٠٠/١	٣٣/٢	٣٣/٢	١٧/٩	٥٠/٩	٣٣/٩	٥٠/٨
Ambiguity and Uncertainty in Situations	١٢/٠	١/٠٠	٨٣/٠	١/٠٠	٣٣/٢	٥٠/٠	٥٠/٨	٦٧/٩	٩/٠٠	٥/٠٠
Added Value	٨٠/٧	٨٣/٨	٦/٠٠	١٧/١	٨٣/٨	٥٠/٩	٤/٠٠	٣٣/٣	٦٧/٠	٣٣/٥
Development of Educational Services	٩٨/٦	٥/٠٠	٥٠/٩	١/٠٠	٨٣/٨	٩/٠٠	٧/٠٠	٤/٠٠	٨٣/١	٤/٠٠
Sector Exploration	٧٣/٦	٦٧/٦	٦/٠٠	٣٣/٤	١٧/٩	٨٣/٨	٣٣/٥	٦٧/٥	٣٣/٣	٣٣/٦
Organizational Exploration	٣٥/٤	٣٣/٤	١/٠٠	٣٣/٠	٣٣/٥	٦٧/٤	٣٣/٧	٣٣/٤	١٧/١	٦٧/٥
Monitoring Documents and Regulations	٤٢/٤	٩/٠٠	٣/٠٠	٦٧/٧	٦/٠٠	٣٣/٥	٣٣/٨	٣٣/٨	١٧/٩	٣٣/٨
Establishment of an Intelligent Information System	٨٥/٥	٨/٠٠	٣٣/٥	٣٣/٦	٦٧/٧	٦٧/٧	٦٧/٥	٦٧/٧	١٧/٩	٦٧/٧
Section Transactions and Exchanges	٢٤/٥	٣٣/٧	٦٧/٦	٤/٠٠	٣٣/٧	٦٧/٧	٣٣/٥	٣٣/٨	٦٧/٧	٧/٠٠

Table 15. Determining the Minimum Distance Between Options

Complexity Section	٢/٠٥٦	Development of Educational Services	٢/٥٧٧	
Cost Reduction	٣/٠٥٢	Sector Exploration	٢/٤٠٦	
Rapid Technological Transformations	٢/٠٥٦	Organizational Exploration	٣/٠٣٩	
Changes in Competitive Conditions	٢/٨٠٦	Monitoring Documents and Regulations	١/٩٤٠	
New Users	١/٢٨٠	Establishment of an Intelligent Information System	١/٣٨٥	
Ambiguity and Uncertainty in Situations	١/٤٢١	Section Transactions and Exchanges	١/٣٨٥	
Added Value	٢/٤٧٢			
Sum of Shortest Distances 74/996		Mean of Shortest Distances 2/206		Standard Deviation of Shortest Distances: 529/0

B: Quantitative Section

In this section, the researcher attempts to test the qualitatively extracted model from the interviews using Structural Equation Modeling (SEM). For this purpose, the researcher intends to use confirmatory factor analysis to analyze the data. These data have been collected from 125 managers of virtual education organizations, as described below.

10. Modeling

Initially, to examine the normality of multivariate data, Mahalanobis distance and the Mardia's skewness test (1971) were employed. Table 16 presents the output of this test after model adjustments.

Table 16. Multivariate Normality Based on Mahalanobis Distance and Mardia's Distribution

Critical Value	Multivariate Kurtosis	Critical Value	Skewness	Maximum	Minimum	Variable
-١,٧٠٨	-٠,٤٢٧	-١,٤١٦	-٠,١٧٧	١٥	٧	**Ali's Conditions**
-٠,٢١٤	-٠,٠٥٤	-٣,٧٥٤	-٠,٤٦٩	١٢	٤	**Phenomenon-Centered**
-٢,٠٤٥	-٠,٥١١	-١,٣٨٠	-٠,١٧٢	١٢	٤	**Strategies**
-٢,٢٦٢	-٠,٥٦٥	-١,٩٣٦	-٠,٢٤٢	٣٦	١٥	**Contextual Conditions**
-١,٧٥٤	-٠,٤٣٨	-١,١٥٣	-٠,١٤٤	١٤	٦	**Intervening Conditions**
-٢,٠٧٤	-٠,٥١٨	-٣,٢٨٠	-٠,٤١٠	١٦	٦	**Outcomes**
				٢,٠٠٩	٢,٣٠٢	**Mediator Statistics**

Given the absolute value of the critical level calculated as 0.392, which is lower than the critical level of 1.96, the multivariate distribution based on the Marida statistic is confirmed with 99% confidence (p = 0.01). Subsequently, the design of the assessment model and the explanation of the level of using blockchain technology with the development of green technology and improving the performance of e-learning and educational software have been carried out using the path analysis method. Therefore, the assumed model for explaining the improvement of e-learning and educational software performance is presented in Figure 1.

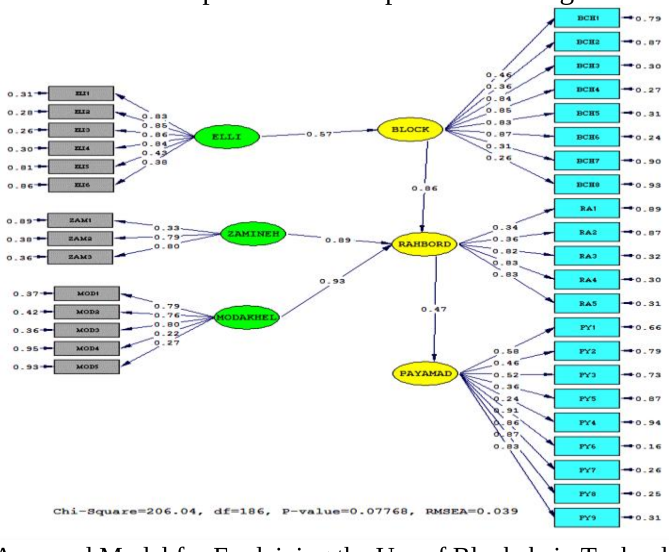


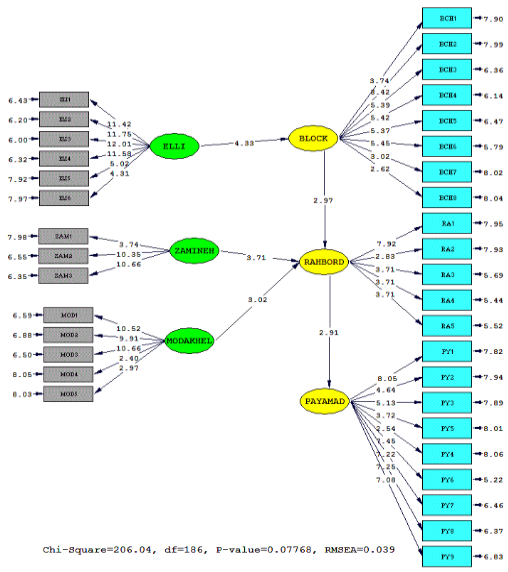
Figure 1. Assumed Model for Explaining the Use of Blockchain Technology in Green Technology Development

Before examining the results of the model estimation, it is essential to review the fit of the assumed model and its indices. Table 17 presents the relevant fit indices. The reason for using model fit programs is that they provide indices that can measure the overall fit of the model with the data. In fact, the overall fit of the model determines how well the model can explain the data. According to Thompson's suggestion, fit indices include the Chi-square test (CMIN), Comparative Fit Index (CFI), Normed Fit Index (NFI), and Root Mean Square Error of Approximation (RMSEA), and these are the most important indices in assessing the model fit (Gamst & Garino, 2006).

Table 17. Fit Indices of the Model Explaining the Use of Blockchain Technology in Green Technology Development

Result	Acceptable Value	Independent Model	Saturated Model	Predicted Model	Index
-	-	۲۸	۱۱۹	۷۸	NPAR
-	-	۱۸۲۵,۷۷	۰	۲۱۸,۸۹	X
-	-	۱۲۵	۰	٤۱	df
Unacceptable	Smaller than	۲۰,۰٦۳	۰	٥,۳۳۹	X/df
Unacceptable	Greater than 9.0	۰	۱	۰,۸۸۰	NFI
Unacceptable	Greater than 9.0	۰	۱	۰,۸۹۷	CFI
Unacceptable	Smaller than 0.8	۰,۲۲۳	-	۰,۱۰۳	RMSEA

The square of Chi-square degree of freedom in the estimated model is 5.34, which is greater than 3 and not acceptable (Kline, 2011). The RMSEA value in the proposed model is 1.103, indicating an unacceptable fit (1.103 > 0.08). Additionally, NFI and CFI statistics should be higher than 0.90, but in this case, these values are 0.88 and 0.89, respectively, indicating unacceptable fit. In conclusion, these numbers suggest that the considered model does not have an appropriate fit with the theoretical model. Consequently, adjustments were made to the model.



Modified Model Explaining the Use of Blockchain Technology in Green Technology Development

Figure 2. illustrates the modifications made to the model. These modifications are detailed in Table 18.

Table 18. Fit Indices for the Modified Model Explaining the Use of Blockchain Technology in Green Technology Development

Outcome	**Estimated Model**	**Index**
-	٧٨	NPAR
-	١١٩,٧٨	X^2
-	٤١	df
Acceptable	٢,٩٢١	X^2/df
Acceptable	٠,٩٣٤	NFI
Acceptable	٠,٩٥٥	CFI
Acceptable	٠,٠٧١	RMSEA

The square of the chi-square over degrees of freedom in the modified model is equal to 2.921. The RMSEA value in the model explaining the use of blockchain technology in the development of green technology is 0.07, indicating an acceptable fit. Additionally, the NFI and CFI statistics should be above 0.90. These numbers indicate that the modified model has a satisfactory fit. Further analysis of the model coefficients and conclusions from the assumptions are discussed below.

Table 19. Multiple Correlation Squared for Improving E-Learning Performance and Green Technology Development

Significance Level	Upper Bound	Lower Bound	Estimation	Source of Change
٠,٠٠٨	٠,٤١٣	٠,٢٨٨	٠,٣٦٤**	Green Technology Development
٠,٠٢٣	٠,٢٠٣	٠,٠٨٧	٠,١٥٩*	Improvement of E-Learning and Educational Software

"Based on the information in Table 19, all predictor variables in the model, namely components of green technology development and blockchain technology usage, collectively have a predictive capability with a mean of 36.0 ($p < 0.01$) from the variance of the mediator variable, i.e., green technology development. Additionally, they have a predictive capability with 16.0 ($p < 0.05$) from the variance of the criterion variable, i.e., improvement of e-learning and educational software. Both coefficients are positive and direct."

Conclusion

The continuous technological advancements and innovations in new educational services that undergo changes and innovation in this field every day make it crucial and vital to pay attention to new interactive and collaborative systems and methods in overall processes in this area, such as blockchain systems. Based on this, the main objective of this research is to identify the components of green technology development in education and training using blockchain technology. To achieve this goal, qualitative research and a data theory approach have been used, and the results and findings in six main areas are discussed. These areas include key conditions, central phenomena, strategies, intervention conditions, background conditions, and consequences, which are elaborated below.

The examination showed that key conditions include sector complexity, uncertainty in situations, accelerating technological changes, integration of technology-focused organizations with education sector organizations, changing competitive conditions, and the strategic importance of the situation. The central phenomenon includes the use of blockchain technology in the development of green technology (education and training), network exploration, competitor monitoring, sector exploration, organizational exploration, document monitoring and legal conditions, creation of an intelligent information system, and sector interactions. Background conditions encompass national conditions (social awareness growth in the virtual education sector, internal country capacity and capabilities), international conditions (modeling successful similar fields, forming an educational consortium to join similar technologies), and organizational conditions (structural dimensions, globalization culture, technological culture, sector awareness). Intervention conditions include internal organizational conditions (structural factors, managerial factors, individual factors) and external organizational conditions (educational conditions, political conditions). Strategies involve the ability to assess and deploy external knowledge, training and empowerment of internal organizations, creating appropriate infrastructure, localizing blockchain technology, collaboration and partnership with successful countries and organizations in this field. Consequences include decentralization, efficiency (efficiency and effectiveness), high access to resources (easy access), information valuation and dynamic data transfer, high security, stability (immutability), and transparency of data, cost reduction, facilitation of the development process of technology infrastructure, timely and real-time tracking and tracking of assets, and ensuring and providing information and transaction exchanges.

The practical applications of blockchain technology in the education software and systems sector include invoicing, teaching and networking, exchange and networking, process automation, data security and management, maintaining the confidentiality of identity information of transaction parties, and sharing resources in the fields of major teaching systems and software. The use of this technology in the education software and systems sector poses challenges, including scalability, security, and speed related to system architecture and the use of appropriate consensus algorithms. Additionally, the operationalization of this technology incurs significant costs. Doner and Lucasani (2021), in their report titled "Blockchain and the Transition of Education Software and Systems," have examined the opportunities and threats of blockchain for local authorities. According to the findings of this report, a precise description of all aspects and challenges of blockchain seems somewhat difficult.

In the quantitative section of the research, the obtained pattern in the qualitative section and the relationships presented in it were evaluated using structural equation modeling and the Lisrel software and were confirmed. Given the findings, it is recommended to develop a detailed regulatory document to regulate and determine the do's and don'ts for starting and using blockchain networks in the e-learning sector, drafted and prepared by the drafting and editing section. Due to the low cost and affordability of knowledge-based technologies in the country, it is suggested that the e-learning sector allocate a specific investment section for the development of blockchain technology and knowledge-based infrastructure in the country for localization of this technology in its main strategies. It is recommended that with limited and well-planned investments, the e-learning sector in the international section allocate blockchain system to be part of the main strategies in international processes and laws in the blockchain field.

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