International Journal of Economics, Management and Accounting

E-ISSN: 3046-9376
P-ISSN: 3048-0396

Review Article

The Impact of Applying the Holonic Manufacturing System on Improving the Quality of Operational Performance in Industrial Organizations

Taher Hameed Abbas Bahia[1] *, Khawlah Radhi Athab[2]

[1] Al- Furat Al-Awsat Technical University, Technical Institute of Dewaniya, Iraq.
e-mail: taher.hemeed.idi22@atu.edu.iq
[2] Al-Qadisiyah University, College of Administration and Economics, Iraq
e-mail: khawlah.alshemary@qu.edu.iq

* Corresponding Author : Taher Hameed Abbas Bahia

Abstract: This study aims to enhance the quality of operational performance by implementing the Holonic Manufacturing System (HMS). The system involves dividing manufacturing processes into autonomous, collaborative, and participatory holons, including the Order Holon, Product Holon, Resource Holon, and Staff Holon. The primary objective is to optimize production efficiency by reducing costs, minimizing processing time, and increasing flexibility while improving overall organizational productivity. The research problem centers on evaluating the impact of holonic manufacturing on operational performance improvement. This study is significant as it addresses a critical issue for firms striving to enhance their efficiency and deliver value to customers. The adoption of HMS is not only a practical approach but also a widely recognized business strategy that has garnered interest from researchers and industry professionals alike.To achieve the study's objectives, a structured questionnaire comprising 36 items was developed and distributed to participants. Two primary hypotheses were formulated to examine the relationship between HMS implementation and operational performance quality. Various statistical analyses were conducted using SPSS (version 24) and AMOS (version 24) to test the hypotheses and validate the findings. The results indicate a significant correlation and causal relationship between the Holonic Manufacturing System and operational performance quality. The findings suggest that implementing HMS effectively enhances organizational performance by improving production processes, increasing efficiency, and reducing operational constraints. Therefore, adopting this system can lead to a more agile, cost-effective, and productive manufacturing environment, making it a valuable strategy for modern organizations.

Keywords: Holonic manufacturing system,Order Holon,Product Holon,Resource Holon,Staff Holon

Received: February 14th 2025;
Revised: February 28th 2025;
Accepted: March 18th 2025;
Online Available : March 25th 2025
Curr. Ver.: March 27th 2025

1. Introduction

The industrial sector faces increasing challenges due to intense global competition and rapid technological advancements. These factors necessitate the adoption of contemporary systems that can enhance efficiency, improve production processes, and meet evolving customer demands. Organizations must continuously innovate to ensure customer satisfaction and loyalty while also maintaining their competitive advantage. The ability to adapt to changing market conditions and technological developments is crucial for industrial firms seeking to expand their market share and sustain long-term growth. In this context, the implementation of advanced manufacturing systems has become essential for achieving operational excellence.

One of the modern approaches to manufacturing that has gained significant attention is the Holonic Manufacturing System (HMS). This system is based on the concept of holons, which are autonomous yet collaborative entities that function independently while interacting within a larger system. HMS integrates different holons, including Order Holon, Product Holon, Resource Holon, and Staff Holon, to create a flexible and adaptive production environment. By ensuring autonomy and cooperation among different manufacturing components, HMS allows organizations to respond dynamically to production variations, optimize resource utilization, and maintain high-quality standards. This approach provides a structured and efficient way to overcome common manufacturing challenges while enhancing productivity.

The quality of operational performance is a critical factor in determining the success of an industrial organization. It serves as a key metric for assessing efficiency, effectiveness, and overall competitiveness. Holonic manufacturing plays a pivotal role in improving operational performance by reducing process delays, minimizing production costs, and increasing flexibility in responding to fluctuating demands. The integration of HMS into industrial settings facilitates real-time decision-making, enhances coordination among production units, and improves workflow efficiency. Consequently, organizations that adopt HMS are better positioned to meet customer expectations and maintain a strong presence in the marketplace.

This study aims to explore the impact of Holonic Manufacturing Systems on operational performance quality. Specifically, it seeks to clarify the concept of holonic manufacturing, examine its benefits, and analyze its correlation with performance enhancement. By investigating the effectiveness of HMS, the study contributes valuable insights into how industrial organizations can leverage this system to achieve superior performance outcomes. The findings of this research can provide a useful framework for companies looking to adopt advanced manufacturing strategies to optimize their operations.

To achieve these objectives, the researcher employed a structured questionnaire to collect primary data regarding the implementation and impact of HMS. The study sample consisted of 65 participants selected from various departments of the Diwaniyah Textiles Factory. The research methodology focuses on assessing the relationship between holonic manufacturing and operational performance through statistical analysis. By examining the perceptions and experiences of professionals working within the manufacturing sector, the study provides empirical evidence on the effectiveness of HMS in improving industrial performance. The insights gained from this research can help manufacturing firms refine their strategies, enhance their operational capabilities, and achieve sustainable growth.

The Study Hypothesis

In accordance with the study's objective, the subsequent two assumptions were established:

- A substantial association exists between the independent variable (holonic manufacturing system) and the dependent variable (Quality of Operational Performance).
- There exists a substantial causal relationship between the independent variable (holonic manufacturing system) and the dependent variable (Quality of Operational Performance).

Sample and Community of the Study

The Diwaniyah Textiles Factory was selected as a practical study site due to its significant contribution to the local community through the provision of exceptional products. The study sample represented the factory's workforce throughout its several departments. Sixty-five questionnaire forms were disseminated to them to address their concerns and elucidate topics pertinent to the investigation. A total of 65 questionnaires were received, resulting in a response rate of 100%.

Statistical Methods Used

The further statistical methodologies employed were: Arithmetic Mean, Standard Deviation, Coefficient of Variation, Relative Significance, Confirmatory Factor Analysis, Correlation Analysis, Regression Analysis. T-test, F-test, Cronbach's Alpha Coefficient.

2. Literature Review

Holonic Manufacturing System(HMS)

The holonic manufacturing system is a type of smart manufacturing system. The concept of utilizing it has arisen as a remedy to address the swift transformations in the corporate landscape, aiming to secure advantages such as crisis stability, adaptability to changes, and efficient resource utilization. The holonic is an independent structural unit that cooperates with other units in The manufacturing system carries out the processing, transportation, and storage operations of materials, parts, and the final product, as well as verifying the quality of information and production requirements, and it may be part of another whole (Babiceanu, 2005:31).

Koestler points out that the holon as a whole is part of a broader whole that contains elements and subparts that provide structure and functional meaning (Pach *etal.*, 2012:1294).

(Leitao & Restivo ,2006:122) see it as a system that has a unique identity, as it allows a new approach to industrialization and possesses the advantages of decentralization and autonomy and its development from The advantageous prospects and research conducted by the Holonian community, along with strategies for maximizing benefits in decentralized systems and methods for monitoring and adapting production. With changes and determining the dynamic behavior of holonic systems.

According to (Hsieh, 2010:1187) sees it as a model for accommodating variables and meeting customer requirements with flexibility and high speed, while (Jana etal., 2014:1) sees it as a system built on the basis of cooperation and joint negotiation between holons based on different functions in the system.

(Derigent *etal.*,2020:1797) see it as a system that has the ability to adapt in real time to the entire organization and to external and internal alterations (abrupt modifications during production or supply, shifts in the dynamics between the client and the supplier, etc.) utilizing the available resources.

According to (Macherki *etal.*, 2021:2) It delineates the entities constituting the production system and the participants in the value chain, which include human, material, cyber, and energy components, and describes the flows exchanged with the entities.

According to (Luca, 2022:78) sees it as a manufacturing system that brings together modern manufacturing activities to meet customer requirements and overcome the challenges faced by traditional systems.

Based on the above, it is one of the smart manufacturing systems characterized by interconnection and cooperation between a series of independent entities, based on absorbing the changes that occur in the production process with complete flexibility, with the aim of reaching optimal situations in manufacturing environments.

Principles of the Holonic Manufacturing

The Holonic manufacturing system is founded on a set of fundamental concepts. autonomy, effectiveness, proactiveness, sociality, cooperation, openness, learning, utility, mobility, and repetitiveness (Derigent etal.,2021:1801); (luca,2022:81); (Oborski&Wysocki,2022:91).

Characters of the Holonic Manufacturing

(Dewa *etal.*, 2014:3) believes that the attributes of the Holonic manufacturing system are encapsulated in:

1. It consists of several holons represented by independent cooperative building blocks.
2. Independence: It refers to the entity's capacity to formulate and oversee the execution of plans and strategies.
3. Collaboration: A process through which a group of acceptable entities is developed that undertakes the planning and implementation tasks of those plans.
4. Structure: A group of holonic systems cooperating to achieve a specific goal, which is to limit the independence of each holon.

Importance of the Holonic Manufacturing

Brennan, (2006:400) believes that the importance of this system can be summarized as follows:

- Crisis handling: that is, providing the best and fastest solutions, identifying machine malfunctions and responding to them, as well as sudden and unexpected operational orders, human errors, and so on.
- Human Integration: Enhanced support and broader application of human intelligence.
- Availability: Ensuring enhanced reliability and maintainability despite the system's complexity and scale.
- Flexibility: The capacity to accommodate alterations in production environments, including the necessity for agility or the utilization of various alternatives, and to facilitate the ongoing evolution of diverse product designs and their combinations.
- Durability: Preserving the system's functionality despite minor and significant failures.

Hsieh, (2009:2563) adds that its importance lies in:

- Allowing workers to take practical action in the industry and giving them autonomy or industrialization in the organization, provided that this is consistent with the general concept of industrialization.
- Enabling working individuals to make the appropriate decision to solve the immediate problems facing them according to their level.
- Increasing the responsibility of individuals, which makes them tied to the work they are responsible for.
- Integrating some workers into all industrial activities to achieve lean manufacturing.
- It stabilizes organizations in the face of the disturbances they face.
- Effective and efficient use of resources available in the organization.
- The ability to deal with variables.
- The ability to renew and expand due to the flexibility of the system.

Objectives of Holonic Manufacturing

Niemann *etal.*, (2018:38-39) pointed to a set of goals:

- Identify an appropriate methodology and structure to facilitate the effective use of manual labor in modern manufacturing systems.
- Facilitating the process of exchanging and managing information related to the implementation of tasks.
- Performance and safety in some important areas through the Holonic system approach based on dividing the complex system into independent and cooperative functional Holonic entities that show great advantages to facilitate human work as flexible resources.
- Effectively exploiting the flexibility and intelligence of the human factor as a resource in exchanging information.
- Integrating modern technology into developing human-machine interaction interfaces.
- Providing a means to achieve quality assurance, which is the goal of every organization.
- Providing a means to verify the design and analyze the production process.

Wasserman, (2022:9) believes that the goals of lean manufacturing are centered on:

- Developing smart manufacturing systems, components, subsystems and supporting tools, as well as linking design, implementation and distribution in an intelligent way.
- Enhance comprehension of manufacturing processes and foster acceptance of Holonic manufacturing system principles.
- Advocate for and establish standards that facilitate the attainment of organizational objectives.
- Diagnosing deviations in the production process and responding quickly in developing appropriate solutions and efficient use of resources.

Dimensions of the Holonic Manufacturing

There were many researchers' points of view in determining the dimensions of this system, but it was agreed to define four basic dimensions called (PROSA) (Product-Resource-Order-Staff Architecture), which are: (Tiwari & Mondal, 2002); (Issa *etal.*, 2014); (Kruger & Basson:2018:3); (Ali, 2023:42)

- Product Holon (PH): It encompasses all requisite information and expertise regarding the manufacturing processes employed to produce products that meet established standards and quality expectations, as it contains consistent and current data about the product life cycle, user requirements, process plans, bill of materials, quality assurance protocols, etc. (Al-Ahbabi, 2023).

- Resource Holon(RH): It is responsible for the function of the resources or production capacity available to be a holon used by other holons in the system. It is responsible for processing information about the resource as It effectively allocates production resources and contains the expertise and methodology to organize, utilize, and manage these resources (Leuvennink, 2018:9). She adds (Ali, 2023:51) that he is responsible for completing the work specified within its deadlines and manages the processing of logistical information related to the work, as it corresponds to the physical entities that are capable of making products, such as factories, machines, and equipment, as it contains all the data and knowledge necessary for all products to provide the ability On the control and regulation of other holons.
- Order Holon(OH): It represents the task of making the product according to the customer's request, as well as managing the physical product according to the logistical controls of production and operations by negotiating with the resource holon to control the behavior of progress through the factory (Vrba, *etal.*, 2011:19).
- Staff Holon(SH): It undertakes the task of providing assistance to other holons in accomplishing their tasks, and focuses on operational processes and empowering workers in order to reduce the workload and complexity of operational processes by providing workers with specialized knowledge (Manesh *etal.*, 2011:390).

Requirements of Holonic Manufacturing System

The requirements of this system are defined as follows: (Fletcher, 2007:343)

- It requires flexible resources used in manufacturing, operating and routing processes between different factory holons.
- Providing a manufacturing environment suitable for tangible and intangible resources to achieve highly diverse and specialized operations.
- Preparing skilled workers and enhancing the role of the skilled worker or operator in making production decisions and solving problems.
- Providing information that enhances the interaction between demand holons, the product, resources, and factory workers.
- It requires achieving streamlined work orders between holons without delay and waiting.
- Rapid response to any malfunction in the system.

Operational Performance(OP)

Operational performance represents a fundamental indicator of the organization's ability to achieve its success by investing the material, technical, human and information resources available to it (Al-Jubouri, 2013:47).

Daft, *etal.*, (2010:18) believe that managers modify the structural and contextual dimensions to more effectively and efficiently transform inputs into outputs and add value.

Leeuw & Berg, (2011:255) defined it as defining, implementing, and using performance measures at the level of daily operations in factories, stores, and warehouses.

Aqdi & Issawi, (2021: 13) indicate that it is a measure of the internal efficiency of the organization, as operations are the foundations upon which it is based in determining the strategic and competitive direction.

The researcher posits that it reflects the extent to which one can ascertain the organization's performance in attaining its objectives and its capacity for enhancement and excellence.

Dimensions of the Performance

Operational performance expresses the broad concept of performance through its interest in operational and transformational processes, and it must be viewed through three basic dimensions: productivity, profitability, and efficiency (Al-Khayyat, 2005: 35). Khanchanapong, *etal.*, (2014:191) indicates that global competition has created challenges for factories to improve their operational dimensions "Quality(Qu), Delivery Time(DT), Flexibility(FL), Cost(Co), and Creativity(Cr)". While Bendickson & Chandler, (2019: 165) indicated that competitive advantage will significantly improve employee productivity, product quality, on-time delivery, flexibility, and creativity, which in their entirety constitute the operational performance of the organization (Al-Janabi & Hassan, 2020: 73), and agree (Mohsen & Al-Najjar,2012:59) that overall performance measures include: quality, delivery, flexibility, low cost, and creativity.

Importance of the Operational Performance

Enhancing performance is a key idea in contemporary society, since robust competition and innovation stem not alone from the utilization of advanced machinery and technology, but also from the most critical resource of all: human workers. The success of any firm may now be assessed by its investment in the capabilities of its employees, their efficiency, and the quality of their performance. Methods for investing in human capital (Al-Anzi & Hatf, 2019: 48).

3. Results and Discussion

The analysis in this study was conducted on a sample of 65 participants, utilizing the SPSS version 24 software to interpret the results obtained. The researcher determined the frequencies, ratios, arithmetic means, standard deviations, and coefficients of variation for the questionnaire items. Furthermore, correlation coefficients and effect coefficients were employed to illustrate the linkages and impacts among the research variables. To assess the reliability and validity of the questionnaire, the researcher employed the Cronbach's alpha coefficient, with the results presented in the subsequent table:

Table1. Cronbach's alpha coefficients

Items	N of Items	Cronbach's Alpha
OH	4	0.82
PH	4	0.88
RH	4	0.93
SH	4	0.88
HMS	16	0.90
Qu	4	0.89
DT	4	0.87
FL	4	0.86
Co	4	0.92
Cr	4	0.88
OP	20	0.92
All Items	36	0.94

The Cronbach's alpha values presented in the table above are near one, signifying the stability and reliability of the researcher's questionnaire.

Repetitions and Ratios of Questionnaire Paragraphs

In order to determine the direction of the research sample through their answers to the paragraphs of the questionnaire prepared by the researcher, the following table was created, this encompasses the outcomes of the repetitions and their ratios for the paragraphs of the (HMS) axis:

Table 2. Frequencies and percentages of (HMS) axis items

Item		Very Low	Low	Medium	High	Very High	Item	Very Low	Low	Medium	High	Very High
OH1	Frequency	0	0	0	53	12	RH1	0	0	0	29	36
	Percent	0	0	0	81.5	18.5		0	0	0	44.6	55.4
OH2	Frequency	0	6	0	24	35	RH2	0	0	0	36	29
	Percent	0	9.2	0	36.9	53.8		0	0	0	55.4	44.6
OH3	Frequency	0	0	0	30	35	RH3	0	0	0	42	23
	Percent	0	0	0	46.2	53.8		0	0	0	64.6	35.4
OH4	Frequency	0	0	0	17	48	RH4	0	0	6	35	24
	Percent	0	0	0	26.2	73.8		0	0	9.2	53.8	36.9
OH	Frequency	0	6	0	124	130	RH	0	0	6	142	112
	Percent	0	2	0	48	50		0	0	2	55	43
PH1	Frequency	0	0	0	29	36	SH1	0	0	12	30	23
	Percent	0	0	0	44.6	55.4		0	0	18.5	46.2	35.4

PH2	Frequency	0	0	0	35	30	SH2	0	0	6	29	30
	Percent	0	0	0	53.8	46.2		0	0	9.2	44.6	46.2
PH3	Frequency	0	0	12	41	12	SH3	0	0	0	24	41
	Percent	0	0	18.5	63.1	18.5		0	0	0	36.9	63.1
PH4	Frequency	0	0	0	30	35	SH4	0	0	0	36	29
	Percent	0	0	0	46.2	53.8		0	0	0	55.4	44.6
PH	Frequency	0	0	12	135	113	SH	0	0	18	119	123
	Percent	0	0	5	52	43		0	0	7	46	47

The results indicate that the largest percentages were observed on the High and Very High scales for the (HMS) axis dimensions, with the (OH) dimension achieving a percentage of 50% from a total of 130 responses, and the (PH) dimension attaining a percentage of 52% from a total of 135 responses. The (RH) dimension attained a percentage of (55%) based on (142) responses, whereas the (SH) dimension achieved a percentage of (47%) from (123) responses.

The subsequent graph illustrates the percentage distribution of responses across the scale for the dimensions of the (HMS

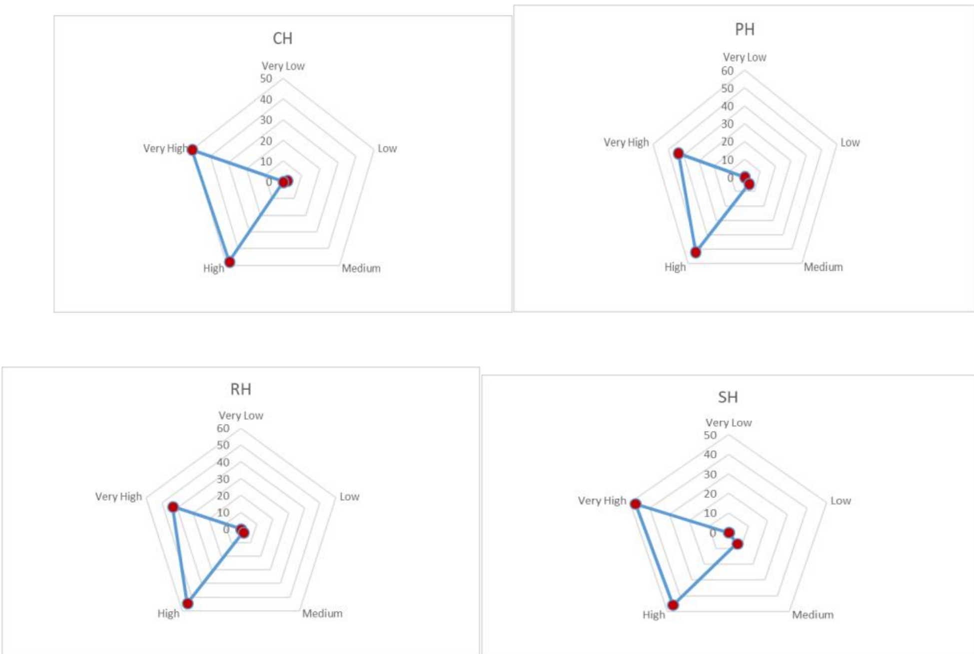


Figure 1. illustrates the percentage of replies for each scale pertaining to the dimension items.

The subsequent table was created, encompassing the outcomes of the repetitions and their corresponding percentages for the paragraphs of the (OP) axis:

Table 3. Frequencies and percentages of (OP) axis items

		Very Low	Low	Medium	High	Very High		Very Low	Low	Medium	High	Very High
Qu1	Frequency	0	0	0	50	15	FL1	0	0	0	30	35
	Percent	0	0	0	76.9	23.1		0	0	0	46.2	53.8
Qu2	Frequency	0	5	0	25	35	FL2	0	0	0	36	29
	Percent	0	7.7	0	38.5	53.8		0	0	0	55.4	44.6
Qu3	Frequency	0	0	0	29	36	FL3	0	0	1	41	23
	Percent	0	0	0	44.6	55.4		0	0	1.5	63.1	35.4
Qu4	Frequency	0	0	0	20	45	FL4	0	0	6	36	23
	Percent	0	0	0	30.8	69.2		0	0	9.2	55.4	35.4
Qu	Frequency	0	5	0	124	131	FL	0	0	7	143	110
	Percent	0	2	0	48	50		0	0	3	55	42
DT1	Frequency	0	0	0	31	34	Co1	0	0	11	31	23
	Percent	0	0	0	47.7	52.3		0	0	16.9	47.7	35.4

DT2	Frequency	0	0	2	36	27	Co2	0	0	6	30	29
	Percent	0	0	3.1	55.4	41.5		0	0	9.2	46.2	44.6
DT3	Frequency	0	0	11	38	16	Co3	0	0	2	26	37
	Percent	0	0	16.9	58.5	24.6		0	0	3.1	40.0	56.9
DT4	Frequency	0	0	0	29	36	Co4	0	0	1	40	24
	Percent	0	0	0	44.6	55.4		0	0	1.5	61.5	36.9
DT	Frequency	0	0	13	134	113	Co	0	0	20	127	113
	Percent	0	0	5	52	43		0	0	8	49	43
Cr1	Frequency	0	0	6	36	23						
	Percent	0	0	9.2	55.4	35.4						
Cr2	Frequency	0	0	11	32	22						
	Percent	0	0	16.9	49.2	33.8						
Cr3	Frequency	0	0	5	30	30						
	Percent	0	0	7.7	46.2	46.2						
Cr4	Frequency	0	0	3	25	37						
	Percent	0	0	4.6	38.5	56.9						
Cr	Frequency	0	0	25	123	112						
	Percent	0	0	10	47	43						

The results indicate that the largest percentages were observed on the High and Very High scales for the (OP) axis dimensions, with the (Qu) dimension achieving a percentage of (50%) from a total of (131) responses, and the (DT) dimension attaining a percentage of (52%) from a total of (134) responses. The percentage for dimension (FL) was 55% with a total of 143 responses, dimension (Co) was 49% with 127 responses, and dimension (Cr) was 47% with 123 responses. The subsequent graph illustrates the percentage distribution of responses on the scale for the dimensions of the (OP) axis:

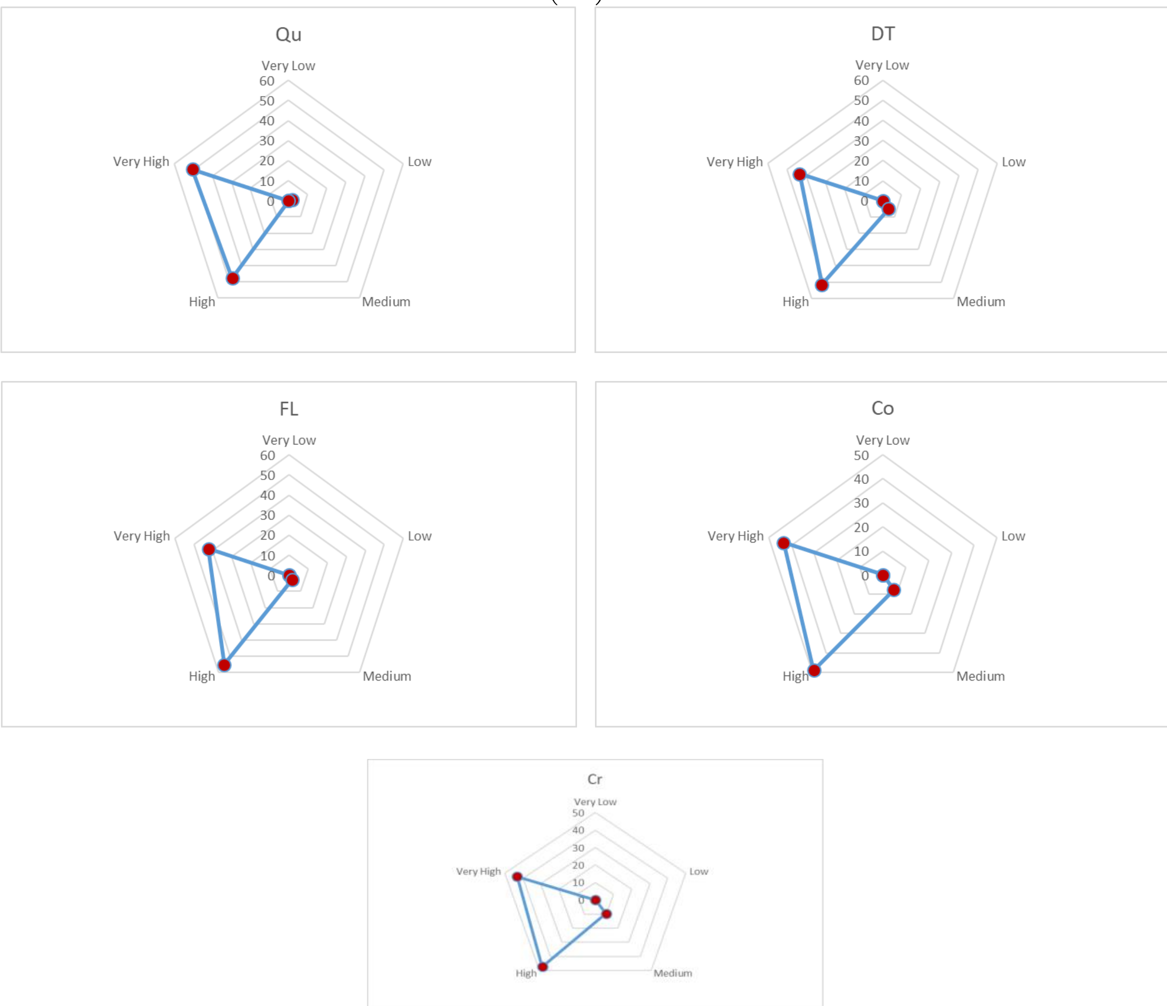


Figure 2. illustrates the response percentages for each scale pertaining to the dimension items.

General Statistics for Questionnaire Items:

The basic statistics for the dimensions and axes of the research were obtained, and the results are presented in the following table, which includes the arithmetic means, standard deviations, and coefficients of variation for the items of the (HMS) axis dimensions.

Table 4. General Statistics for HMS Axis Dimensions

Item	Mean	Std. Deviation	CV	Item	Mean	Std. Deviation	CV
OH1	4.18	0.391	9	RH1	4.55	0.501	11
OH2	4.35	0.891	20	RH2	4.45	0.501	11
OH3	4.54	0.502	11	RH3	4.35	0.482	11
OH4	4.74	0.443	9	RH4	4.28	0.625	15
OH	4.45	0.379	9	RH	4.40	0.394	9
PH1	4.55	0.501	11	SH1	4.17	0.720	17
PH2	4.46	0.502	11	SH2	4.37	0.651	15
PH3	4.00	0.612	15	SH3	4.63	0.486	11
PH4	4.54	0.502	11	SH4	4.45	0.501	11
PH	4.38	0.380	9	SH	4.40	0.430	10

The aforementioned results indicate that the responses predominantly align with the High and Very High scales, while the standard deviations are minimal, signifying a higher degree of homogeneity in the responses of the research sample. The researcher created graphic representations of the coefficient of variation values for each paragraph of the (HMS) axis:

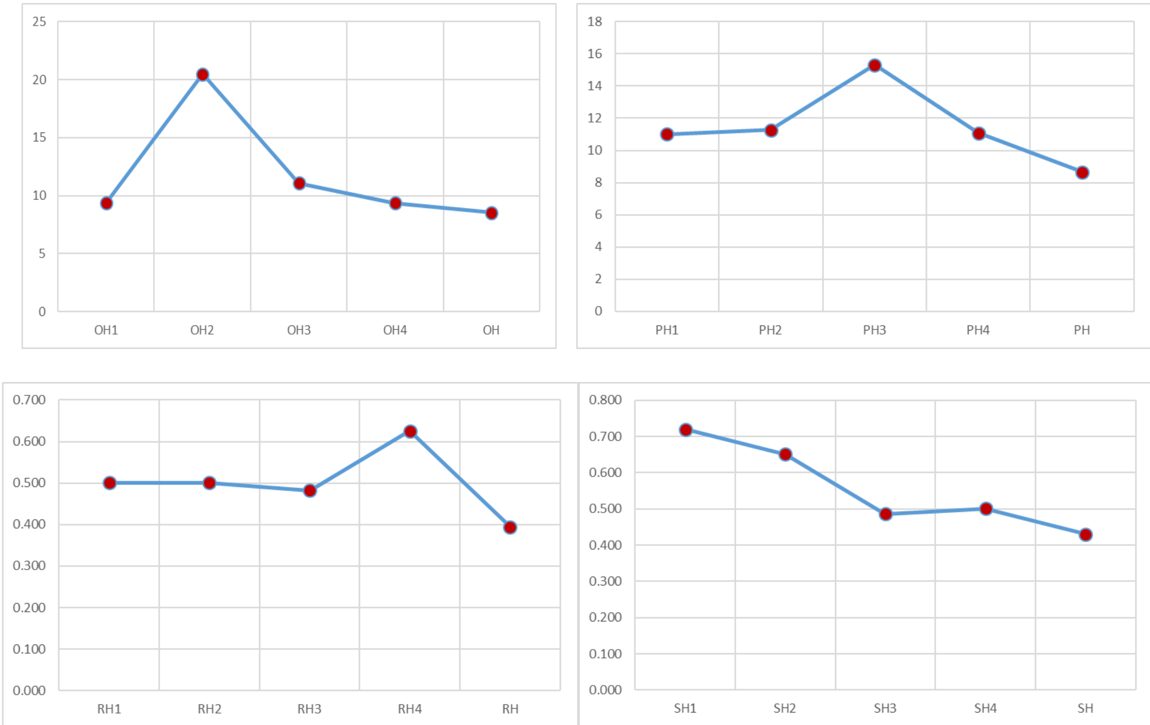


Figure 3. Coefficient of variation for (HMS) axis dimensions' paragraphs

The subsequent table presents the arithmetic means, standard deviations, and coefficients of variation for the paragraphs of the (OP) axis dimensions:

Table 5. General Statistics for Paragraphs of Axis Dimensions (OP)

Item	Mean	Std. Deviation	CV	Item	Mean	Std. Deviation	CV
Qu1	4.23	0.425	10	FL1	4.54	0.502	11

Qu2	4.38	0.842	19	FL2	4.45	0.501	11
Qu3	4.55	0.501	11	FL3	4.34	0.509	12
Qu4	4.69	0.465	10	FL4	4.26	0.619	15
Qu	4.4654	0.36678	8	FL	4.3962	0.40958	9
DT1	4.52	0.503	11	Co1	4.18	0.705	17
DT2	4.38	0.550	13	Co2	4.35	0.648	15
DT3	4.08	0.645	16	Co3	4.54	0.561	12
DT4	4.55	0.501	11	Co4	4.35	0.513	12
DT	4.3846	0.39300	9	Co	4.3577	0.45279	10
Cr1	4.26	0.619	15				
Cr2	4.17	0.698	17				
Cr3	4.38	0.630	14				
Cr4	4.52	0.589	13				
Cr	4.3346	0.45560	11				

The results indicate that responses predominantly align with the High and Very High scales, while the low standard deviations suggest a stronger homogeneity in the responses of the research sample. The researcher generated the subsequent graphs illustrating the coefficients of variation for each paragraph of the (OP) axis:

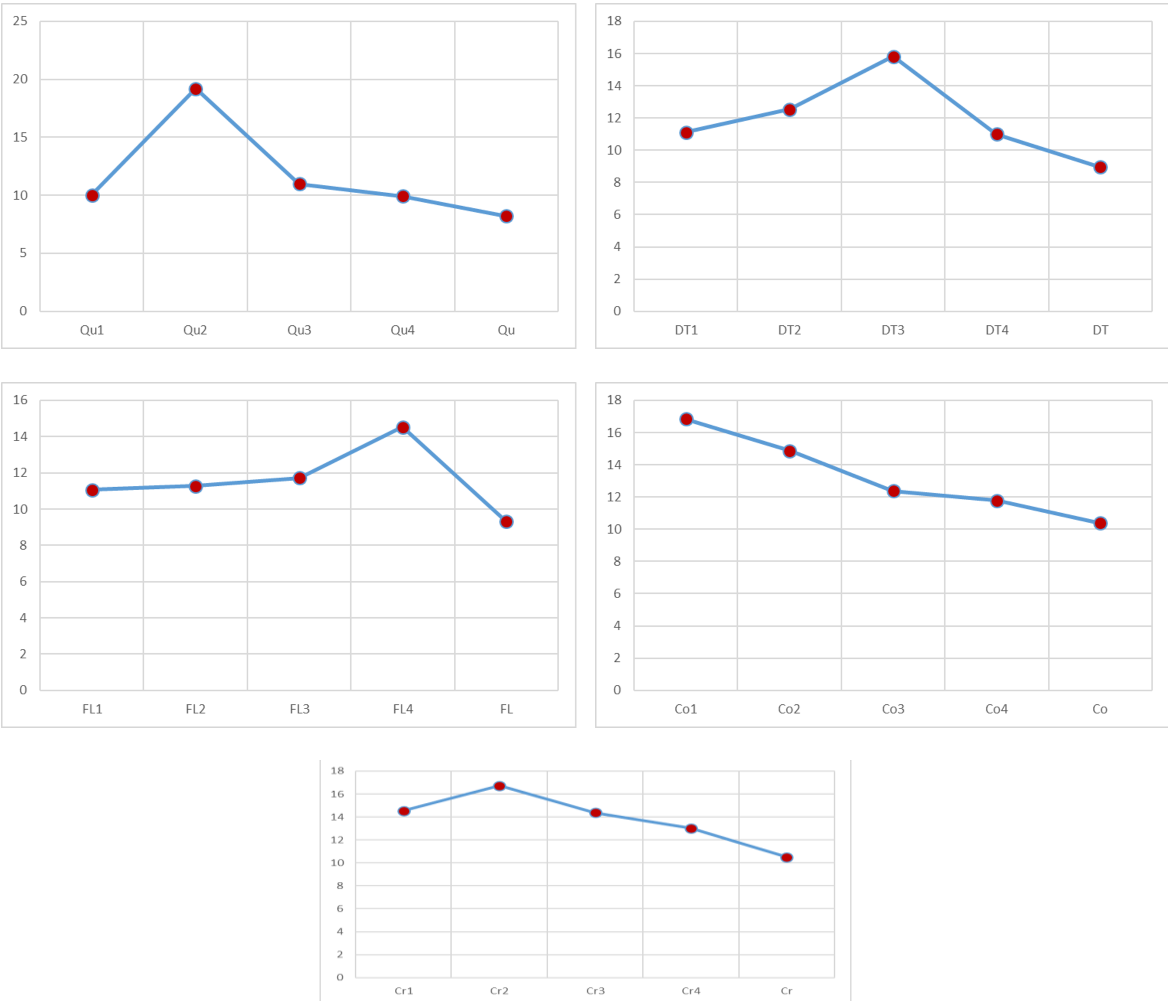


Figure 4. Coefficient of variation for (OP) axis dimensions' paragraphs

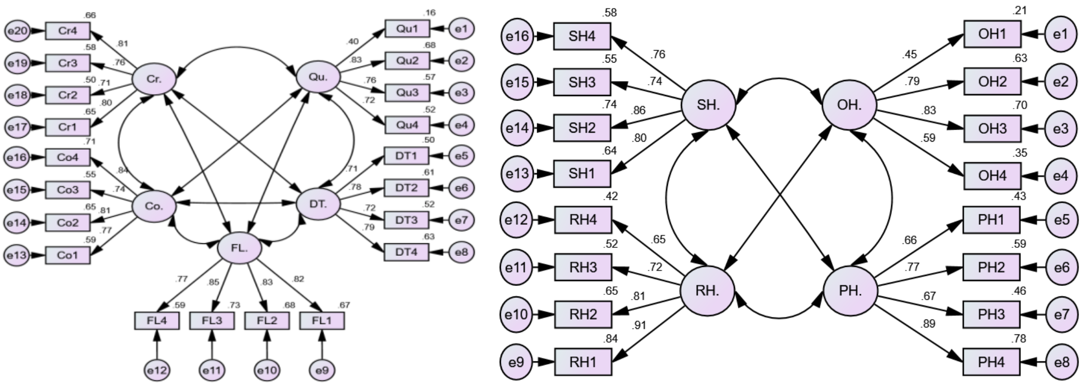
Confirmatory Factor Analysis of Questionnaire Axes

To develop a model chart for identifying paragraphs and their explanatory dimensions, the researcher employed confirmatory factor analysis and determined the corresponding regression weights. The researcher identified criteria for assessing the model's accuracy, including the ratio of the chi-square value to the degrees of freedom, the comparative fit index (CFI), the Tucker-Lewis index (TLI), and the root mean square error of approximation (RMSEA), as detailed in the subsequent table containing these values.

Table 6. Criteria and determination for the acceptance or rejection of forms

Parameter	OP			HMS		
	Parameter Value	Comparison	Decision	Parameter Value	Comparison	Decision
X^2(df) (sig.)	395.980 (98) (0.000)	Less than 0.05	Accepted	700.322 (160) (0.000)	Less than 0.05	Accepted
CFI	0.90	More than 0.50	Accepted	0.84	More than 0.50	Accepted
TLI	0.83	More than 0.50	Accepted	0.80	More than 0.50	Accepted
RMSEA	0.00	Less than 0.05	Accepted	0.00	Less than 0.08	Accepted

The aforementioned results demonstrate the capacity of the paragraphs to assess the axis to which they are assigned. The researcher utilized the AMOS program to construct the structural diagram of the dimensions pertaining to the two axes under investigation, as illustrated in the subsequent pictures:



HMS ***OP***

Figure 5. illustrates the structural plan detailing the proportions of the two axes.

The standard regression weights indicate that the paragraphs associated with each dimension have interpreted their respective dimensions with varying values. This is what we observe through the values established on the linear paths connecting the dimension to the paragraphs. The subsequent table presents the standard regression weights for the two axes:

Table 7. presents the conventional regression weights for each paragraph.

Item path			Estimate	Item path			Estimate
OH1	<---	OH.	.454	Qu1	<---	Qu.	.404
OH2	<---	OH.	.793	Qu2	<---	Qu.	.827
OH3	<---	OH.	.834	Qu3	<---	Qu.	.756
OH4	<---	OH.	.592	Qu4	<---	Qu.	.723
PH1	<---	PH.	.657	DT1	<---	DT.	.706
PH2	<---	PH.	.768	DT2	<---	DT.	.779
PH3	<---	PH.	.675	DT3	<---	DT.	.722
PH4	<---	PH.	.885	DT4	<---	DT.	.795

Item path			Estimate	Item path			Estimate
RH1	<---	RH.	.914	FL1	<---	FL.	.817
RH2	<---	RH.	.807	FL2	<---	FL.	.827
RH3	<---	RH.	.719	FL3	<---	FL.	.853
RH4	<---	RH.	.650	FL4	<---	FL.	.766
SH1	<---	SH.	.799	Co1	<---	Co.	.769
SH2	<---	SH.	.861	Co2	<---	Co.	.805
SH3	<---	SH.	.741	Co3	<---	Co.	.744
SH4	<---	SH.	.764	Co4	<---	Co.	.840
				Cr1	<---	Cr.	.804
				Cr2	<---	Cr.	.707
				Cr3	<---	Cr.	.762
				Cr4	<---	Cr.	.810

Correlation Test

The researcher computed the correlations and their significance between the two axes and their respective dimensions. The null hypothesis established for testing is that there is no significant connection between the (HMS) axis and the (OP) axis at a significance level of (0.05). The correlation coefficients were calculated and presented in the subsequent table

Table 8. The correlation between the two axes and their dimensions

Correlations						
		OH	PH	RH	SH	HMS
Qu	Pearson Correlation	.591**	.567**	.511**	.672**	.681**
	Sig. (2-tailed)	.000	.000	.000	.000	.000
	N	65	65	65	65	65
DT	Pearson Correlation	.605**	.566**	.567**	.812**	.743**
	Sig. (2-tailed)	.000	.000	.000	.000	.000
	N	65	65	65	65	65
FL	Pearson Correlation	.571**	.602**	.623**	.702**	.725**
	Sig. (2-tailed)	.000	.000	.000	.000	.000
	N	65	65	65	65	65
Co	Pearson Correlation	.574**	.610**	.658**	.636**	.718**
	Sig. (2-tailed)	.000	.000	.000	.000	.000
	N	65	65	65	65	65
Cr	Pearson Correlation	.723**	.608**	.566**	.600**	.720**
	Sig. (2-tailed)	.000	.000	.000	.000	.000
	N	65	65	65	65	65
OP	Pearson Correlation	.689**	.663**	.659**	.763**	.805**
	Sig. (2-tailed)	.000	.000	.000	.000	.000
	N	65	65	65	65	65
**. Correlation is significant at the 0.01 level (2-tailed).						

The table indicates a correlation value of 0.805 between the HMS axis and the OP axis, which is significant as the significance value of zero is below the 0.05 threshold. This signifies the dismissal of the null hypothesis and the endorsement of the alternative hypothesis. We determine that a direct and substantial association exists between the (HMS) axis and the (OP) axis at a significance level below (0.05).

The correlation coefficient between the (OH) and (OP) axes was 0.689, which is significant as the significance value of zero is below the 0.05 threshold. This signifies the dismissal of the null hypothesis and the endorsement of the alternative hypothesis. We determine that a direct and substantial correlation exists between the (OH) and (OP) axes below the (0.05) significance threshold. The correlation coefficient between PH and the OP axis was 0.663, which is statistically significant as the significance value of zero is below the 0.05 threshold. This signifies the dismissal of the null hypothesis and the endorsement of the alternative hypothesis. We determine that a direct and substantial connection exists between the (PH) and (OP) axes at a significance level below (0.05). The correlation coefficient between the (RH) and (OP) axes was (0.805), a statistically significant value below the (0.05) significance threshold, as the significance value was less than (0.05). This indicates the rejection of the null hypothesis and the acceptance of the alternative hypothesis. We ascertain a direct and substantial association between (RH) and the (OP) axis at a significance level of (0.05). The correlation coefficient between (SH) and the (OP) axis was (0.763), a statistically significant value at a significance level of (0.05), as the significance value was below (0.05), indicating the rejection of the null hypothesis and the acceptance of the alternative hypothesis. We determine that a direct and substantial connection exists between (SH) and the (OP) axis at a significance level of (0.05).

The subsequent figure visually illustrates the correlation values between the (HMS) axis and its dimensions, as well as the (OP) axis:

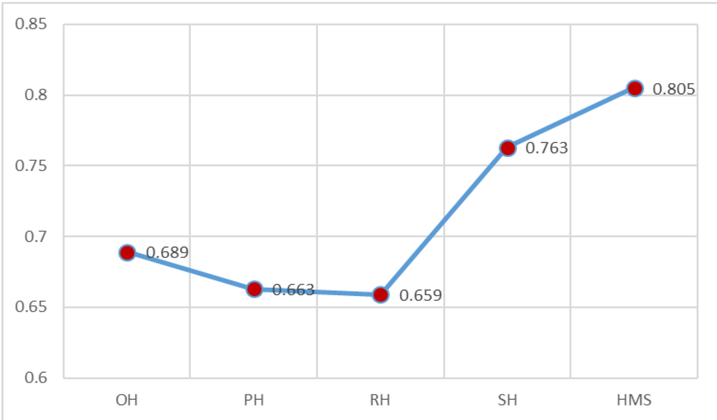


Figure 6. illustrates the correlation values between the (HMS) axis and its dimensions, as well as between (OP).

Effect of (HMS) and its dimensions on (OP)

The hypothesis proposed by the researcher to assess the impact of (HMS) on (OP) is as follows:

H0: There is no major impact of the (HMS) axis and its size on the (OP) axis.

versus alternate hypothesis:

H1: The (HMS) axis and its dimensions exert a substantial influence on the (OP) axis.

Subsequent to data analysis, the aforementioned null hypothesis was evaluated by examining the results pertaining to the effect, as illustrated in the accompanying table:

Table 9. Results of impact analysis

Response variable	Explanatory variable	R Square	F test	Sig. of F test	Standardized Regression coefficient	t test	Sig. of t test
OP	HMS	.647	115.683	.000	.805	10.756	.000
	OH	.475	56.980	.000	.689	7.549	.000
	PH	.440	49.495	.000	.663	7.035	.000
	RH	.434	48.316	.000	.659	6.951	.000
	SH	.582	87.690	.000	.763	9.364	.000

The findings indicate that the coefficient of determination for the HMS effect model on OP was 64%, signifying that the model accounted for 64% of the overall variance, while the remaining variance is attributed to other variables not considered in this study. The F test value was 115.683, which is significant as the significance value of zero is less than the 0.05 threshold. The regression parameter or effect value was 0.805, with a t-test result of 10.756, which is significant at the 0.05 level, showing a substantial direct influence. We infer that a one-unit increase in the (HMS) value results in a (0.805) rise in the (OP) value. The coefficient of determination for the (OH) effect model on (OP) was 47%, indicating that the model accounted for 47% of the total variance, while the remaining variance was attributed to other variables not considered in this study. The F test value was 56.980, which is significant due to a Sig. value of 0.805. Equal to zero is inferior to the 0.05 significance level. The regression parameter value is 0.689, with a t-test statistic of 7.549, indicating significance below the 0.05 level. This signifies the existence of a substantial direct effect. We deduce that a one-unit increase in the value of (OH) results in a corresponding rise of (0.689) in the value of (OP).

The coefficient of determination for the PH effect model in OP was 44%, indicating that the model accounted for 44% of the entire variance, while the remaining variance was attributed to other factors not included in this study. The F test value was 49.495, which is significant as the significance value is zero, falling below the 0.05 threshold. The regression parameter or effect value was 0.663, with a t-test value of 7.035, which is significant at the 0.05 level, showing a substantial direct influence. We deduce that a one-unit increase in pH results in a 0.663 increase in OP value. The coefficient of determination for the relative humidity effect model in the operational phase was 43%, indicating that the model accounted for 43% of the total variance, while the remaining variance was attributed to other variables not considered in this study. The F test value was 48.316, which is significant due to a significance value of 0.663. Equal to zero is below the 0.05 significance threshold. The regression parameter value was 0.659, with a t-test result of 6.951, which is significant at the 0.05 level, showing a substantial direct influence. Consequently, we deduce that a one-unit increase in the value of (RH) results in a (0.659) rise in the value of (OP). The coefficient of determination for the SH effect model on OP was 58%, indicating that the model accounted for 58% of the overall variance, while the remaining was attributed to other factors not included in this study. The F test value was 87.690, which is significant since the Sig. value of zero is less than the 0.05 significance limit. The regression parameter value was 0.763, with a t-test result of 9.364, indicating significance below the 0.05 level. This signifies a substantial direct influence, leading us to conclude that a one-unit rise in (SH) results in a (0.763) increase in (OP).

Conclusions

Upon examining the topics presented in the literature, assessing the data, and analyzing the outcomes, the following conclusions were drawn: The questionnaire is distinguished by its stability and dependability, with the largest percentages observed in the High and Very High scales for the majority of the (HMS) axis dimensions, as well as for most of the (OP) axis dimensions. The conventional regression weights derived from the confirmatory factor analysis indicated that the items associated with each dimension represented their respective dimensions with varying values. The results demonstrate a direct and substantial association between the (HMS) axis and the (OP) axis at a 5% significance level. It demonstrated a direct and substantial association between (OH) and the (OP) axis beneath the (5%) significance threshold. A direct and substantial association exists between (PH) and the (OP) axis below the (5%) significance threshold. A direct and substantial association exists between (RH) and the (OP) axis below the (5%) significance threshold. A direct and substantial association exists between (SH) and the (OP) axis at a significance level of (5%). The analysis revealed a substantial positive effect, indicating that a one-unit rise in (HMS) results in a 0.805 increase in (OP). A notable direct effect exists, leading us to conclude that a one-unit rise in (OH) results in a (0.689) increase in (OP). A notable direct effect exists; thus, we deduce that a one-unit increase in the (PH) value results in a 0.663 increase in the (OP) value. Similarly, a significant direct effect indicates that a one-unit increase in the (RH) value leads to a 0.659 increase in the (OP) value. A notable direct effect exists, indicating that a one-unit rise in (SH) results in a (0.763) increase in (OP). The researcher emphasizes the importance of focusing on the implementation of the holographic manufacturing system, a contemporary manufacturing approach that diminishes costs, shortens processing and delivery times, and enhances factory flexibility. Also, setting plans and policies to develop employees and raise their skills, knowledge and relationships on an ongoing basis within the framework of performance improvement objectives.

References

1) Al-Ahbabi, T. F. M. (2023). Possibility implementation of the Holonic Manufacturing System by adopting the Lean Six Sigma requirements: The mediating role of the Lean Supply Chain Standards (Doctoral dissertation, Tikrit University).
2) Al-Enezi, Q. M., & Hatf, H. H. (2019). Total quality and its role in improving the operational performance of employees. Al-Muthanna Journal of Administrative and Economic Sciences, 9(1).
3) Ali, E. F. (2023). The possibility of applying holonic and fractal manufacturing systems to achieve the efficiency of the manufacturing system (Doctoral dissertation, Al-Qadisiyah University, Iraq).
4) Al-Janabi, Y. N., & Hassan, S. B. (2020). Improving operational performance through simulating the Holonic Manufacturing System. Journal of Economics and Administrative Sciences, 26(121).
5) Al-Jubouri, M. A. J. (2013). The clarity of operational performance standards and its role in improving operations management decisions (Master's thesis, Mosul University, Iraq).
6) Al-Khayyat, Z. S. (2005). Total quality management requirements and operational performance of banks (Master's thesis, University of Mosul, Iraq).
7) Al-Najjar, S. M., & Mohsen, A. K. (2012). Production and operations management (4th ed.). Wael Publishing.
8) Babiceanu, R. (2005). Holonic-based control system for automated material handling systems (Doctoral dissertation, Virginia Polytechnic Institute and State University).
9) Bendickson, J. S., & Chandler, T. D. (2019). Operational performance: The mediator between human capital developmental programs and financial performance. Journal of Business Research, 94.
10) Brennan, R. (2006). Towards the assessment of holonic manufacturing systems. 12th IFAC/IFIP/IFORS/IEEE/IMS Symposium on Information Control Problems in Manufacturing, Saint-Etienne, France.
11) Daft, R. L., Murphy, J., & Willmott, H. (2010). Organization theory and design (10th ed.). South-Western, Cengage Learning.
12) Derigent, W., Cardin, O., & Trentesaux, D. (2020). Industry 4.0: Contributions of holonic manufacturing control architectures and future challenges. Journal of Intelligent Manufacturing, 32.
13) Derigent, W., Cardin, O., & Trentesaux, D. (2021). Industry 4.0: Contributions of holonic manufacturing control architectures and future challenges. Journal of Intelligent Manufacturing, 32(7).
14) Dewa, M. T., Matope, A. F., Van D. M., & Nyanga, L. (2014). Holonic control system: A proposed solution for managing dynamic events in a distributed manufacturing environment. SAIIE26 Proceedings Conference, Muldersdrift, South Africa.
15) Fletcher, M. (2007). Evaluating the Prometheus methodology through a case study on designing an agent-based holonic control system. International Journal of Manufacturing Research, 2(3).
16) Hsieh, F. (2010). Design of reconfiguration mechanism for holonic manufacturing systems based on formal models. Engineering Applications of Artificial Intelligence, 23.
17) Hsieh, F. (n.d.). Holarchy formation and optimization in holonic manufacturing systems I. Automatica, 45.
18) Issa, H., Ostrosi, E., Lenczner, M., & Habib, R. (2014). Discontinuous phenomena of holonic design: Functional completeness versus solution completeness. Procedia CIRP, 21.
19) Jana, T., Bairagi, B., Paul, S., Sahnawaj, S., Sarkar, B., & Saha, J. (2014). Multi-objective scheduling in an agent-based holonic manufacturing system. Decision Science Letters, 3.
20) Khanchanapong, T., Prajogo, D., Sohal, A. S., Cooper, B. K., Yeung, A. C., & Cheng, T. C. E. (2014). The unique and complementary effect of manufacturing technologies and lean practices on manufacturing operational performance. International Journal of Production Economics, 153.
21) Kruger, K., & Basson, A. (2018). JADE multi-agent system holonic control implementation for a manufacturing cell. Department of Mechanical and Mechatronic Engineering, Stellenbosch University, South Africa.
22) Leeuw, S., & Berg, J. (2011). Improving operational performance by influencing shopfloor behavior via performance management practices. Journal of Operations Management, 29.
23) Leitao, P., & Restivo, F. (2006). ADACOR: A holonic architecture for agile and adaptive manufacturing control. Computers in Industry, 57.
24) Leuvennink, J. C. (2018). The integration of human workers as resource holons in a holonic manufacturing cell (Master's thesis, Stellenbosch University).
25) Luca, A. (2022). Developing a holonic shop floor control system using MANPrro for agent-to-agent communications. Intelligent Systems Group; SOS-Conference.
26) Macherki, D., Diallo, T. M. L., Choley, J.-Y., Guizani, A., Barkallah, M., & Haddar, M. (2021). QHAR: Q-Holonic-based architecture for self-configuration of cyber–physical production systems. Applied Sciences, 11.
27) Niemann, J., Basson, A., Fussenecker, C., Kruger, K., Schlosser, M., & Turek, S. (2018). Implementation of eye-tracking technology in holonic manufacturing systems. ScienceDirect, Procedia - Social and Behavioral Sciences, 238.
28) Oborski, P., & Wysocki, P. (2022). Intelligent visual quality control system based on convolutional neural networks for holonic shop floor control of Industry 4.0 manufacturing systems. Advances in Science and Technology Research Journal, 16(2).
29) Okdi, A., & Issawi, A. (2021). The impact of the resource planning system on the operational performance of the institution. Faculty of Economic, Commercial and Management Sciences, Ahmed Draya University, Adrar, Algeria.
30) Pach, C., Bekrar, A., Zbib, N., Sallez, Y., & Trentesaux, D. (2012). An effective potential field approach to FMS holonic hierarchical control. Control Engineering Practice, 20.
31) Tiwari, M., & Mondal, S. (2002). Application of an autonomous agent network to support the architecture of a holonic manufacturing system. International Journal of Advanced Manufacturing Technology, 20.

32) Vrba, P., Tichý, P., Marik, V., Hall, K., Stron, R., Maturana, F., & Kadera, P. (2011). Rockwell Automation's holonic and multiagent control systems compendium. IEEE Transactions on Systems, Man, and Cybernetics – Part C: Applications and Reviews, 41(1).
33) Wasserman, A. (2022). ARTI-based holonic control implementation for a manufacturing system using the BASE architecture.