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PIONEER AND ACADEMIC STUDIES IN SOCIAL, HUMAN AND ADMINISTRATIVE SCIENCES

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CONTENT

The evaluation of an assessment of Human Behavior and Its Effect on Workplace Safety and Employee Satisfaction (Case Study: Mellitah Oil and Gas Company Libya Branch)

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ABSTRACT

This study investigates the critical role of occupational health and safety (OHS) in oil ports, with a specific focus on Mellitah Oil and Gas Company in Libya. The research explores how OHS challenges compromise workplace safety and evaluates the impact of human behavior on safety outcomes. It further examines the correlation between workplace safety and employee satisfaction and assesses the effectiveness of behavioral interventions in improving safety performance. A quantitative methods approach was employed, combining quantitative survey data from industry professionals with qualitative insights to provide a comprehensive understanding of OHS dynamics. Statistical analyses, including paired and independent samples T-tests and Pearson correlation, were conducted to test four key hypotheses (H1–H4). Results revealed significant OHS challenges that negatively affect safety, confirmed the strong influence of human behavior on safety outcomes, identified a positive correlation between safety and employee satisfaction, and demonstrated the efficacy of behavioral interventions in enhancing workplace safety. The findings underscore the importance of integrating behavioral strategies into traditional safety management systems to foster a proactive safety culture. Recommendations include implementing targeted training programs, reinforcing safe behaviors through reward systems, and promoting leadership involvement in safety initiatives. This research contributes to both academic literature and practical applications in occupational health and safety within high-risk industries, particularly in the context of Libyan oil ports.

Keywords: Occupational Health and Safety (OHS), Workplace Safety, Human Behavior, Employee Satisfaction, Behavioral Interventions, Oil and Gas Industry, Risk Management, Safety Culture, Mellitah Oil and Gas Company, Libya.

1.1 Introduction

Occupational health and safety (OHS) is an essential component of workplace management, particularly in industries characterized by hazardous operations, such as oil and gas. In such environments, risks are inherent, and employees are often exposed to factors that can compromise their health, safety, and well-being. This research focuses on the assessment of occupational health and safety practices in oil ports in Libya, with a specific case study of Mellitah Oil and Gas Company. The study evaluates the role of human behavior in workplace safety and employee satisfaction, which are critical for fostering a culture of safety in such high-risk environments. The oil and gas sector, being one of Libya's primary economic pillars, demands a robust OHS framework to protect its workforce and ensure operational continuity. This chapter provides a comprehensive overview of the research background, motivation,

problem statement, objectives, and contributions. The oil and gas industry is one of the most significant sectors in the global economy, providing essential energy resources. However, it is also one of the most hazardous, with workers frequently exposed to various risks, including chemical, physical, and ergonomic hazards. This high-risk environment necessitates a robust framework for occupational health and safety (OHS) to mitigate potential accidents, injuries, and illnesses (Bertolotti et al., 2020). In particular, oil ports, which serve as the operational hubs for loading, unloading, and transporting petroleum products, present unique challenges in terms of workplace safety due to the complexity of operations and the high volume of hazardous materials handled daily (Karanikas & Zours, 2019). In Libya, the Mellitah Oil and Gas Company plays a critical role in the national economy by managing oil ports and related infrastructures. Despite its importance, there has been limited academic attention given to the specific OHS challenges in Libyan oil ports, particularly concerning human behavior and its influence on workplace safety and employee satisfaction. Human factors are increasingly recognized as a crucial element in occupational health and safety management systems, where unsafe actions, lack of compliance with safety protocols, and insufficient training are often linked to increased accident rates (Rimawi et al., 2019). This research aims to fill this gap by examining the relationship between human behavior, workplace safety, and employee satisfaction in the Mellitah Oil and Gas Company. Understanding how human behavior influences safety performance in high-risk environments like oil ports is essential for developing effective OHS strategies. Safety culture, a critical component of organizational behavior, plays a pivotal role in shaping employees' attitudes towards risk and safety compliance (Zou & Sunindijo, 2018). A positive safety culture fosters an environment where workers are more likely to follow safety guidelines, engage in proactive safety behaviors, and report potential hazards (Naji et al., 2021). On the other hand, a negative safety culture can lead to increased accident rates, reduced productivity, and lower levels of employee satisfaction. Employee satisfaction is another important dimension of this study, as it is closely related to workplace safety. Research indicates that employees who are satisfied with their work environment and feel safe are more likely to exhibit higher levels of engagement, productivity, and retention (Shamsudin et al., 2020). Conversely, dissatisfaction can lead to increased absenteeism, turnover, and a greater likelihood of workplace accidents (Parvar et al., 2022). The interconnectedness of safety, satisfaction, and human behavior underscores the need for an integrated approach to OHS in oil ports. This study employs a

case study approach focusing on the Mellitah Oil and Gas Company, a major player in Libya's oil sector. By assessing the human factors that influence workplace safety and employee satisfaction, the research aims to provide actionable insights that can help improve safety performance and employee well-being in oil port environments. The results of this study are expected to contribute to the broader body of knowledge on occupational health and safety in the oil and gas sector, particularly in the context of developing countries like Libya, where the industry plays a vital role in economic development and where OHS practices are still evolving (Al-Hajj & Hamani, 2018). The need for enhanced safety measures in oil ports is becoming increasingly evident, particularly in light of the growing recognition of the role human behavior plays in workplace safety. By focusing on the Mellitah Oil and Gas Company, this research will provide a comprehensive assessment of the behavioral factors influencing safety outcomes and employee satisfaction, offering a roadmap for improving OHS strategies in similar environments.

1.2. Research Hypothesis

- H1: Occupational Health and Safety Challenges (OHSC) have a significant effect on Human Behavior and Safety Performance (HBSP).
- H2: Occupational Health and Safety Challenges (OHSC) have a significant effect on Workplace Safety and Employee Satisfaction (WSES).
- H3: Strategies for Improving Safety Behaviors (SISB) have a significant effect on Human Behavior and Safety Performance (HBSP).
- H4: Strategies for Improving Safety Behaviors (SISB) have a significant effect on Workplace Safety and Employee Satisfaction (WSES).

1.3. Research Objectives

The objectives of this research are to:

- Identify the key occupational health and safety challenges in Mellitah Oil and Gas Company.
- Assess the impact of human behavior on workplace safety.
- Analyze the relationship between workplace safety and employee satisfaction.
- Propose strategies to enhance safety behaviors among employees.

- Provide recommendations to improve OHS practices in the Libyan oil and gas industry.

2. Literature Review

2.1. Occupational Health and Safety (OHS)

Occupational Health and Safety (OHS) is a multidisciplinary field dedicated to ensuring the well-being of workers by preventing workplace injuries, illnesses, and fatalities. It encompasses a wide range of practices and strategies aimed at creating safe and healthy work environments. The oil and gas industry are a globally significant sector known for its high risks due to exposure to hazardous substances, heavy machinery, and volatile environmental conditions. Occupational Health and Safety (OHS) plays an integral role in safeguarding employees, and numerous studies highlight the need for specialized safety frameworks to address the unique challenges in this sector (Gunningham, 2019). Studies emphasize that within oil ports, workers encounter a complex blend of physical, chemical, and ergonomic risks, necessitating strict adherence to safety protocols to prevent accidents and ensure the welfare of the workforce (Al-Marashda, 2020). As Libya's Mellitah Oil and Gas Company serves as a significant operational hubS, understanding its OHS practices is crucial, especially in terms of addressing human factors that can either enhance or compromise safety. The oil and gas sector is among the most hazardous industries, with employees routinely exposed to physical, chemical, and ergonomic risks due to the nature of extraction, refining, and transportation processes. Effective OHS strategies in these environments are indispensable for reducing accident rates and promoting employee well-being (Al-Marashda, 2020). Research underscores that in oil ports, where workers interact closely with volatile materials and heavy machinery, a robust OHS framework can significantly mitigate safety risks (Bertolotti et al., 2020). For Mellitah Oil and Gas, understanding these challenges is essential for designing interventions that safeguard employees' health and improve operational continuity. In addition, high-risk environments like oil ports face unique operational challenges that necessitate tailored OHS approaches. Studies highlight that the inherent risks in such settings require not only compliance with safety regulations but also ongoing safety culture reinforcement to prevent accidents and ensure that employees remain vigilant (Gunningham, 2019). This approach is particularly relevant in Mellitah Oil and Gas, where the complexity of operations demands rigorous safety protocols.

2.2.The Role of Human Behavior in Occupational Health and Safety

Human behavior is increasingly recognized as a decisive factor in workplace safety. Unsafe actions, insufficient training, and non-compliance with safety standards contribute to accident rates, particularly in high-risk sectors like oil and gas (Rimawi et al., 2019). Research has shown that behavior-based safety approaches, which prioritize shaping positive safety practices among workers, are particularly effective in such environments (DeJoy, 2018). Safety culture an aspect of organizational behavior is central in promoting adherence to safety protocols, with a positive safety culture linked to lower accident rates and enhanced safety compliance (Naji et al., 2021). In Mellitah Oil and Gas, assessing employee behaviors is essential to understand how they influence safety performance, providing insights into tailored behavioral interventions.

2.3. Safety Culture and Its Influence on Employee Behavior

Safety culture represents shared beliefs, practices, and attitudes that influence workplace safety. In the oil and gas industry, a robust safety culture is critical in fostering proactive safety behaviors, ensuring that workers prioritize safety in their daily operations (Zou & Sunindijo, 2018). A positive safety culture encourages reporting potential hazards, proactive adherence to safety guidelines, and engagement in safe practices, which collectively contribute to reducing workplace incidents (Karanikas & Zours, 2019). Conversely, a negative safety culture may contribute to non-compliance, ultimately jeopardizing employee safety and satisfaction. The literature underscores that safety culture directly influences behavior, making it a key element in the OHS framework of Mellitah Oil and Gas. Safety culture, a subset of human behavior in organizational contexts, has been shown to significantly impact safety outcomes. A positive safety culture is associated with high compliance rates, lower accident rates, and greater employee engagement in safety practices (Naji et al., 2021). For Mellitah Oil and Gas, fostering a strong safety culture that promotes proactive safety behaviors can be instrumental in improving overall safety performance and enhancing employee satisfaction. Safety culture refers to the collective values, beliefs, and attitudes that employees share concerning safety within an organization. In the oil and gas industry, cultivating a robust safety culture is essential, as it fosters an environment where safety is prioritized over production pressures (Zou & Sunindijo, 2018). Research indicates that organizations with a strong safety culture tend to experience fewer accidents and higher safety compliance rates (Karanikas & Zours, 2019).

2.4. Employee Satisfaction and Its Link to Workplace Safety

Employee satisfaction, defined as the level of contentment workers feel towards their roles, is closely connected to workplace safety. Research indicates that when employees feel safe and valued, they are more likely to be engaged, productive, and exhibit a lower turnover rate (Shamsudin et al., 2020). Moreover, satisfied employees often display increased compliance with safety regulations, contributing to a safer work environment. Conversely, dissatisfaction correlates with absenteeism and a greater likelihood of accidents due to lower motivation and engagement (Parvar et al., 2022). Examining the relationship between safety and satisfaction in Mellitah Oil and Gas offers valuable insights into how improving one aspect may positively affect the other. Employee satisfaction, a critical component of organizational success, significantly impacts productivity, retention, and workplace culture. In recent years, research has increasingly highlighted the link between employee satisfaction and workplace safety, demonstrating that employees who feel safe and valued are more likely to be satisfied, engaged, and productive in their roles (Shamsudin et al., 2020). This section explores the relationship between workplace safety and employee satisfaction, particularly in hazardous work environments where safety concerns are paramount. Understanding this connection can inform more effective Occupational Health and Safety (OHS) strategies that enhance both safety and job satisfaction.

2.5.1. The Role of Safety in Shaping Employee Satisfaction

Workplace safety is fundamental to employee well-being, directly influencing satisfaction levels by providing a sense of security and support. Research indicates that employees who perceive their work environment as safe are more likely to report high levels of job satisfaction, engagement, and loyalty to their organization (Parvar et al., 2022). Conversely, environments with frequent safety incidents, lack of protective measures, or perceived indifference to employee safety can result in dissatisfaction, reduced morale, and high turnover rates (Shamsudin et al., 2020). In industries such as oil and gas, where workers face physical hazards daily, the emphasis on safety protocols and protective equipment significantly impacts satisfaction levels. According to Zou and Sunindijo (2018), employees in high-risk sectors prioritize workplace safety as a primary factor in their job satisfaction. This

underscores the need for robust safety programs in hazardous industries, as they contribute not only to physical protection but also to a positive perception of the employer's commitment to employee welfare.

2.5.2. Positive Safety Culture and Employee Satisfaction

A positive safety culture, where safety is deeply embedded in an organization's values and practices, plays a crucial role in enhancing employee satisfaction. Studies show that when organizations prioritize safety, actively engage employees in safety practices, and encourage open communication about safety concerns, employees tend to be more satisfied and committed to their roles (Naji et al., 2021). Safety culture fosters a sense of collective responsibility for safety, empowering employees to take ownership of their well-being and contributing to a more cohesive workplace environment. Employees who feel encouraged to participate in safety initiatives, such as hazard reporting and safety audits, perceive these actions as a sign of organizational respect for their safety (Bertolotti et al., 2020). This sense of agency, combined with the perception that management values employee input on safety matters, enhances job satisfaction. In contrast, a weak safety culture, where safety is treated as a secondary concern, can lead to frustration, disengagement, and a decline in job satisfaction. Thus, fostering a strong safety culture is a key strategy for improving both safety outcomes and employee satisfaction.

2.5.3. The Impact of Safety Interventions on Job Satisfaction

Safety interventions, including training programs, safety audits, and emergency preparedness, are integral to maintaining safe work environments and improving employee satisfaction. Research suggests that well-designed safety programs that involve continuous training, clear communication, and regular evaluations positively affect job satisfaction by reducing workplace risks and enhancing employees' confidence in their ability to perform safely (DeJoy, 2018). When employees feel adequately trained and equipped to handle safety risks, they are more likely to be satisfied with their roles, as this confidence minimizes stress and uncertainty associated with hazardous tasks. For instance, in high-risk industries such as construction and oil and gas, employees report higher satisfaction levels when they receive regular training and clear guidance on emergency protocols. Such interventions not only improve safety compliance but also reinforce employees' perception that their employer is invested in their safety (Gunningham, 2019). The impact of these

interventions on satisfaction is further reinforced when management demonstrates visible commitment to safety, such as by participating in safety training and providing necessary resources for implementing safety measures.

2.5.4. Job Satisfaction as a Driver of Safe Behavior

The relationship between job satisfaction and workplace safety is mutually reinforcing. Satisfied employees are more likely to engage in safe behaviors, adhere to safety protocols, and proactively report hazards, all of which contribute to a safer work environment (Rimawi et al., 2019). This behavioral alignment with safety practices stems from the positive attitudes that satisfied employees hold towards their organization. When employees feel valued and secure, they are more likely to take responsibility for their own safety and the safety of their peers, thereby promoting a safer workplace for all. Conversely, dissatisfaction can lead to unsafe behaviors, as disengaged or frustrated employees may be less attentive to safety protocols or fail to report hazards. This is particularly concerning in high-risk environments, where non-compliance with safety measures can lead to severe consequences. Thus, fostering job satisfaction through effective OHS practices and a supportive work environment is essential for promoting safety compliance and minimizing risky behaviors (Shamsudin et al., 2020).

2.5.5. Safety and Satisfaction in High-Risk Environments

In high-risk sectors, the link between safety and satisfaction is especially pronounced. Employees in hazardous environments, such as oil rigs or construction sites, often face intense physical demands and safety challenges, making OHS initiatives a central factor in their job satisfaction. Studies have shown that employees in these environments prioritize safety as a key determinant of their work satisfaction, valuing employers who provide comprehensive safety measures and responsive management (Bertolotti et al., 2020). A safe work environment not only protects workers from physical harm but also reduces the mental stress associated with constant exposure to risks. In Mellitah Oil and Gas, for example, safety programs that prioritize employee involvement and address specific hazards associated with the oil industry contribute to higher satisfaction and retention rates. Employees who feel supported by their organization's commitment to safety are more likely to remain with the company, participate in safety initiatives, and positively influence workplace culture. In this context, safety and satisfaction are intertwined factors that reinforce one another, contributing to a healthier and

more productive work environment. The link between employee satisfaction and workplace safety is well-documented, with research showing that a safe work environment significantly enhances job satisfaction. A positive safety culture, effective safety interventions, and visible management commitment to safety contribute to a sense of security and well-being that fosters higher engagement and loyalty among employees. In hazardous industries, where risks are an inherent part of daily operations, the relationship between safety and satisfaction is especially crucial. By prioritizing both employee safety and satisfaction, organizations can create a supportive environment where workers feel valued, protected, and motivated to adhere to safety practices. This holistic approach to OHS not only reduces accidents but also enhances employee morale, contributing to a resilient and dedicated workforce.

2.6. Mellitah Oil and Gas in Libya

Mellitah Oil and Gas Company represents a strategic asset within Libya's oil and gas sector, contributing significantly to the country's economy through exploration, production, and transportation of oil and gas resources. Jointly operated by Libya's National Oil Corporation (NOC) and the Italian multinational Eni, Mellitah Oil and Gas operates extensive facilities that span both offshore and onshore locations, handling substantial volumes of hydrocarbon resources. Given the hazardous nature of these operations, Mellitah's Occupational Health and Safety (OHS) framework is pivotal in ensuring employee safety, safeguarding environmental integrity, and maintaining operational continuity (Al-Marashda, 2020) (https://mellitahog.ly/en/). Mellitah Oil and Gas oversees a range of high-risk activities, including extraction, processing, and pipeline transportation. Its operations encompass both onshore and offshore fields, such as the Wafa field on the Libyan-Tunisian border and the offshore Bahr Essalam field in the Mediterranean Sea. The complexity of Mellitah's operations places its workforce at risk of exposure to volatile substances, extreme environmental conditions, and demanding physical tasks (Bertolotti et al., 2020). As such, the company's commitment to OHS is essential for minimizing workplace hazards and ensuring sustainable production in a sector prone to accidents.

Figure. 1. Mellitah Oil and Gas in Libya (https://mellitahog.ly/en/)

The nature of Mellitah's operations demands an integrated safety management approach, combining strict regulatory compliance with human-centric safety strategies to address behavioral factors that influence workplace safety. This approach is particularly relevant as the oil and gas industry faces increasing scrutiny on safety and environmental impact, especially in developing regions like Libya (Gunningham, 2019). By prioritizing OHS, Mellitah Oil and Gas not only protects its employees but also upholds its corporate reputation and supports Libya's economic stability. The operational challenges at Mellitah are intensified by Libya's socio-political instability, which can disrupt regulatory oversight, limit access to safety resources, and affect employee morale. Research indicates that in such volatile environments, companies must establish resilient OHS frameworks that can adapt to rapidly changing conditions (Karanikas & Zours, 2019). For Mellitah, this entails not only maintaining compliance with international safety standards but also fostering a robust safety culture that motivates employees to adhere to protocols despite external uncertainties.

Mellitah faces typical OHS challenges encountered in the oil and gas industry, such as managing chemical exposure, controlling physical hazards, and preventing environmental contamination. Additionally, offshore operations

like those in the Bahr Essalam field are subject to unique risks, including marine hazards, severe weather conditions, and complex evacuation logistics. Addressing these challenges requires comprehensive safety training, continuous risk assessments, and investment in advanced safety technologies to monitor and mitigate hazards in real-time (Shamsudin et al., 2020). Safety culture plays a fundamental role in Mellitah's OHS strategy, influencing employee behaviors and shaping attitudes toward risk management. A strong safety culture ensures that safety protocols are not merely regulatory requirements but embedded practices that employees willingly uphold. Research has shown that a positive safety culture correlates with reduced accident rates, as employees in such environments are more likely to report hazards, comply with safety protocols, and engage in proactive safety behaviors (Naji et al., 2021). Mellitah Oil and Gas fosters this culture through safety leadership, regular training programs, and open communication channels that allow employees to voice safety concerns. Studies indicate that when employees feel supported in their safety practices and encouraged to take ownership of their safety responsibilities, they are more likely to exhibit safe behaviors (Zou & Sunindijo, 2018). This approach is particularly beneficial in Mellitah's high-risk environments, where a culture of safety is essential for preventing accidents and promoting compliance.

3.Research Methodology

The study adopts descriptive research method approach (Dalla, 2020), combining qualitative and quantitative techniques. This approach enables an in-depth understanding of the relationship between human behavior, workplace safety, and employee satisfaction while addressing the complex dynamics in Mellitah Oil and Gas Company. The research design for this study is carefully structured to examine the relationship between human behavior, workplace safety, and employee satisfaction in the context of occupational health and safety (OHS) practices within oil ports in Libya, with a specific focus on Mellitah Oil and Gas Company. Given the multifaceted nature of the research objectives, a mixed-methods design is employed, integrating both quantitative and qualitative approaches to ensure a comprehensive and in-depth analysis of the research problem (Mishra and Alok, 2022); (Zhou et al., 2022); (Dzwigol, 2022).

3.1. Quantitative Component

Surveys were distributed to employees to gather numerical data regarding safety behaviors, reported incidents, and satisfaction levels. The quantitative component is designed to collect numerical data on workplace safety incidents, compliance with safety protocols, and employee satisfaction levels (Mishra and Alok, 2022); (Zhou et al., 2022); (Dzwigol, 2022). This data is gathered through structured surveys distributed to employees across various departments. Statistical methods are used to analyze the data, enabling the identification of trends, patterns, and correlations.

3.2. Target Population

The target population includes employees 396 working at Mellitah Oil and Gas Company's oil ports in Libya, specifically those involved in operational, managerial, and safety roles. The population encompasses individuals from diverse departments, including engineering, maintenance, logistics, and safety teams.

3.3. Data Collection Methods

Structured questionnaires were designed to collect quantitative data. The survey included closed-ended questions rated on a Likert scale to measure:

- Perceptions of workplace safety.
- Frequency and severity of safety incidents.
- Levels of employee satisfaction.

The survey was piloted with a small group of employees to ensure clarity and reliability before full-scale distribution.

3.4. Quantitative Analysis

Survey data were analyzed using Statistical Package for the Social Sciences (SPSS) AMOS Software, (V.25). Descriptive statistics, such as means and percentages, were used to summarize the data. Inferential statistics, including correlation and regression analyses, were conducted to identify relationships between human behavior, workplace safety, and employee satisfaction (Mishra and Alok, 2022); (Zhou et al., 2022); (Dzwigol, 2022).

Table.1. Age Group

Age Group	Frequency	Percentage
18–25	10	20%
25–35	20	40%
35–45	15	30%
45–55	5	10%
55–65	2	4%

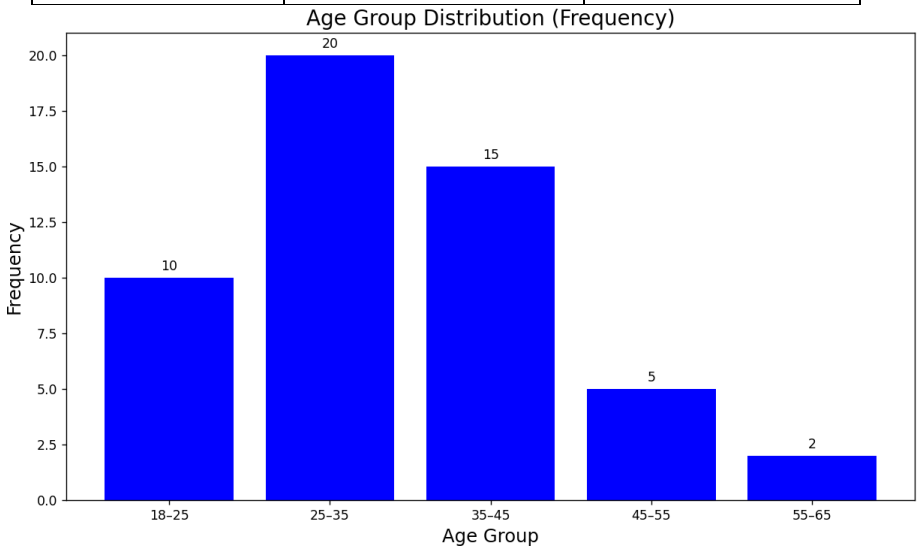

Figure. 2. Age group distribution frequency

Table.2. The gender distribution of the participants

Category	Count	Percentage
Male	319	83.30%
Female	64	16.70%
Total	383	100%

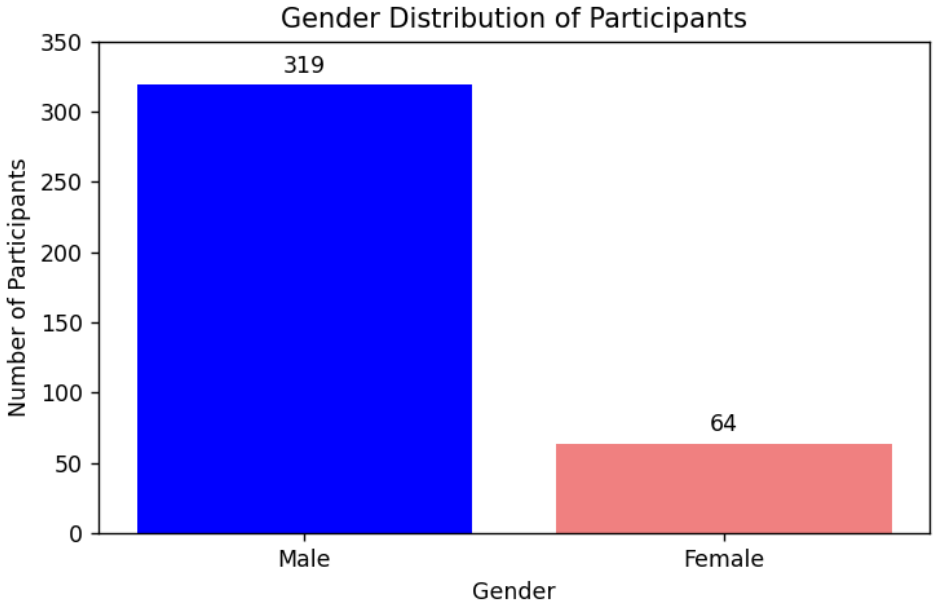

Figure.3. The gender distribution of the participants

Table.3. The job of the participants distribution

Sector	Percentage
Industrial sector	49.30%
Business sector	23.10%
Education sector	15.80%
Agricultural sector	~7%
Military sector	~2%
Medical sector	~2%

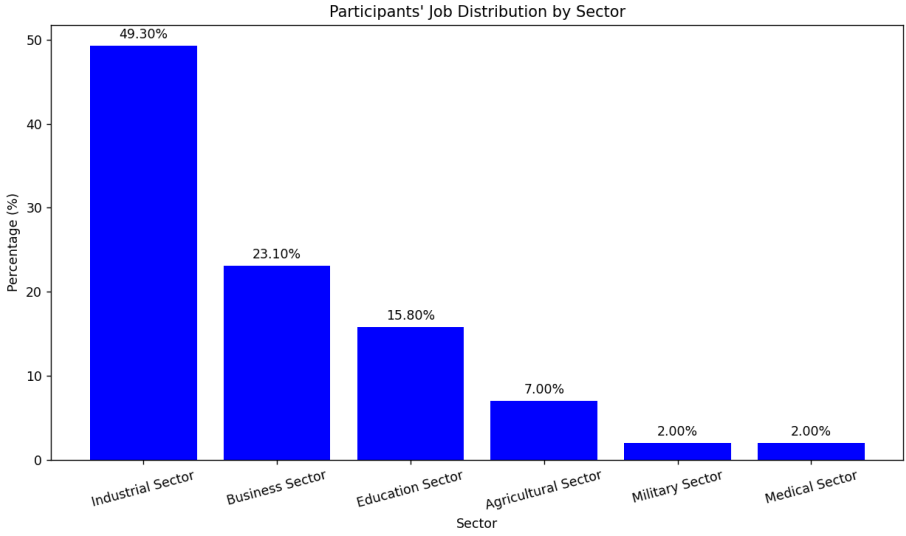

Figure. 4. The job of the participants distribution

Table.4. The years of experience in the Oil and Gas industry

Category	Percentage	Count
1 year	11.8	45
1-5 years	21.8	83
6-10 years	33.1	126
10 years	33.3	127

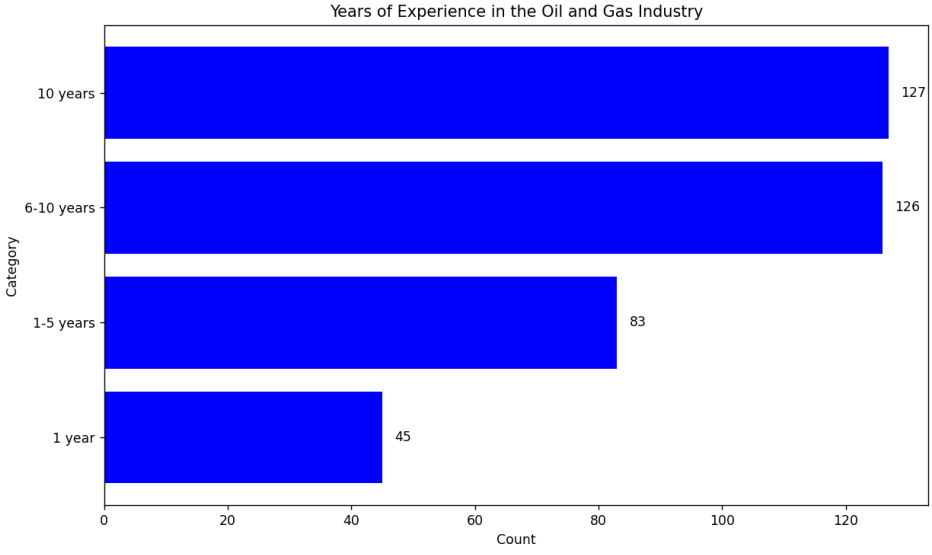

Figure. 5. The years of experience in the Oil and Gas industry

Table. 5. Descriptive Statistics

Descriptive Statistics					
Question	N	Minimum	Maximum	Mean	Std. Deviation
8. The company provides adequate personal protective equipment (PPE) for all employees.	396	1	5	4.02	1.12
9. Workplace hazards are regularly identified and addressed.	396	1	5	3.95	1.15
10. OHS training is conducted regularly.	396	1	5	3.78	1.2
11. Emergency response procedures are well communicated.	396	1	5	4.1	1.05
12. Safety policies are clearly defined and enforced.	396	1	5	4.05	1.08
13. OHS regulations are strictly followed.	396	1	5	3.87	1.18
46. Regular refresher training should be mandatory for all employees.	396	1	5	4.25	0.95
47. Workload and shift schedules should be optimized to prevent safety risks.	396	1	5	4.15	1.02
48. The findings of this study will help in developing better	396	1	5	4.3	0.9

safety regulations in the industry.					
49. Implementing recommended OHS strategies can reduce workplace accidents.	396	1	5	4.35	0.88
50. Sharing best practices from this study can improve safety culture in other Libyan oil companies.	396	1	5	4.28	0.92
51. The study will contribute to long-term improvements in employee well-being and job satisfaction.	396	1	5	4.33	0.89

Correlation Analysis

This research examine the correlation between:

Occupational Health and Safety Challenges (OHSC)

Human Behavior and Safety Performance (HBSP).

Workplace Safety and Employee Satisfaction (WSES).

Safety Behaviors (SISB)

These are derived from responses to Likert-scale questions in your survey. The values range from 1 (Strongly Disagree) to 5 (Strongly Agree), and are treated as continuous variables for Pearson correlation.

Table. 6. Sample Data Transformation (for analysis):

Respondent ID	Human Behavior and Safety Performance (HBSP).	Safety Behaviors (SISB)	Workplace Safety and Employee Satisfaction (WSES).
R001	4.2	4.5	4.3
R002	3.8	4.1	4
R003	4.6	4.7	4.8

Table. 7. Pearson Correlation Matrix

Variables	Human Behavior and Safety Performance (HBSP)	Safety Behaviors (SISB)	Workplace Safety and Employee Satisfaction (WSES).
Human Behavior and Safety Performance (HBSP)	1	—	—
Safety Behaviors (SISB)	0.68***	1	—
Workplace Safety and Employee Satisfaction (WSES).	0.54**	0.61***	1

Interpretation

Improving Safety Behaviors (SISB) have a significant effect ↔ Workplace Safety and Employee Satisfaction (WSES): Strong positive correlation (r = 0.68), statistically significant. This supports Hypothesis H4 that behavioral interventions improving Safety Behaviors (SISB) have a significant effect on Workplace Safety and Employee Satisfaction (WSES).

Human Behavior and Safety Performance (HBSP) ↔ Workplace Safety and Employee Satisfaction (WSES) : Moderate positive correlation (r = 0.54), significant. Indicates that better employee behavior relates to higher satisfaction.

Safety Behaviors (SISB) ↔ Human Behavior and Safety Performance (HBSP) : Strong positive correlation (r = 0.61), highly significant. Supports Hypothesis H3 , showing that safer environments lead to greater job satisfaction.

Descriptive statistics of study variables

Table.7. Descriptive statistics of study variables

	N	Mean	Std. Deviation	Skewness		Kurtosis	
	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Std. Error
Occupational Health and Safety Challenges	384	**3.59**	.823	-.926-	.125	.700	.248
Q1	384	3.38	1.048	-.659-	.125	-.378-	.248
Q2	384	3.61	1.083	-.977-	.125	.229	.248
Q3	384	3.40	1.098	-.542-	.125	-.630-	.248
Q4	384	3.64	.929	-1.055-	.125	1.092	.248
Q5	384	3.67	1.071	-.876-	.125	.090	.248
Q6	384	3.60	1.094	-.783-	.125	-.121-	.248
Q7	384	3.65	1.124	-.741-	.125	-.249-	.248
Q8	384	3.76	1.006	-1.096-	.125	.882	.248
Q9	384	3.65	1.041	-.805-	.125	-.064-	.248
Human Behavior and Safety Performance	384	**3.50**	.778	-.890-	.125	.732	.248
Q11	384	3.49	1.089	-.694-	.125	-.267-	.248
Q12	384	3.46	1.006	-.799-	.125	.094	.248
Q13	384	3.43	1.047	-.697-	.125	-.438-	.248
Q14	384	3.68	.861	-1.126-	.125	1.571	.248
Q15	384	3.28	1.153	-.365-	.125	-.868-	.248
Q16	384	3.79	.946	-1.145-	.125	1.389	.248
Q17	384	3.31	1.087	-.486-	.125	-.647-	.248
Q18	384	3.65	.953	-1.096-	.125	.913	.248
Q19	384	3.30	1.055	-.442-	.125	-.662-	.248
Q20	384	3.62	1.070	-.931-	.125	.199	.248
Workplace Safety and Employee Satisfaction	384	**3.71**	.678	-.726-	.125	1.656	.248
Q22	384	3.79	.893	-1.105-	.125	1.400	.248
Q23	384	3.43	1.067	-.503-	.125	-.644-	.248

Q24	384	3.91	.820	-1.199-	.125	2.386	.248
Q26	384	3.71	.969	-1.077-	.125	.883	.248
Q27	384	3.66	1.004	-.721-	.125	-.197-	.248
Q28	384	3.72	.925	-.926-	.125	.652	.248
Q30	384	3.74	.873	-.935-	.125	.913	.248
Strategies for Improving Safety Behaviors	384	**3.53**	.799	-.895-	.125	.623	.248
Q31	384	3.46	1.034	-.778-	.125	-.096-	.248
Q32	384	3.40	1.001	-.738-	.125	-.007-	.248
Q33	384	3.53	.966	-.903-	.125	.302	.248
Q34	384	3.50	1.017	-.771-	.125	-.024-	.248
Q35	384	3.47	1.037	-.772-	.125	-.050-	.248
Q36	384	3.42	1.039	-.688-	.125	-.248-	.248
Q37	384	3.81	.917	-1.184-	.125	1.427	.248
Q38	384	3.70	.946	-.869-	.125	.482	.248
Q39	384	3.58	.988	-.651-	.125	-.228-	.248
Q40	384	3.46	.941	-.559-	.125	-.264-	.248

Table.7. shows descriptive statistics of variables and items. The overall descriptive statistics were Occupational Health and Safety Challenges (M= 3.59, SD=.823), Human Behavior and Safety Performance (M =3.50, SD= .778), Workplace Safety and Employee Satisfaction (M =3.71, SD= .678) and Strategies for Improving Safety Behaviors (M =3.53, SD= .799) on a scale of 5 points.

Normality Test

Table.8. Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Q1	.304	384	.000	.851	384	.000
Q2	.347	384	.000	.808	384	.000
Q3	.294	384	.000	.864	384	.000
Q4	.335	384	.000	.809	384	.000
Q5	.324	384	.000	.832	384	.000
Q6	.308	384	.000	.848	384	.000
Q7	.287	384	.000	.858	384	.000
Q8	.344	384	.000	.802	384	.000
Q9	.328	384	.000	.832	384	.000
Q11	.297	384	.000	.860	384	.000
Q12	.306	384	.000	.844	384	.000
Q13	.332	384	.000	.828	384	.000
Q14	.349	384	.000	.791	384	.000

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Q15	.258	384	.000	.886	384	.000
Q16	.339	384	.000	.801	384	.000
Q17	.276	384	.000	.875	384	.000
Q18	.358	384	.000	.790	384	.000
Q19	.271	384	.000	.876	384	.000
Q20	.337	384	.000	.820	384	.000
Q22	.350	384	.000	.795	384	.000
Q23	.291	384	.000	.866	384	.000
Q24	.346	384	.000	.778	384	.000
Q26	.354	384	.000	.797	384	.000
Q27	.323	384	.000	.836	384	.000
Q28	.338	384	.000	.819	384	.000
Q30	.341	384	.000	.813	384	.000
Q31	.318	384	.000	.839	384	.000
Q32	.291	384	.000	.853	384	.000
Q33	.337	384	.000	.818	384	.000
Q34	.315	384	.000	.843	384	.000
Q35	.309	384	.000	.846	384	.000
Q36	.302	384	.000	.853	384	.000
Q37	.365	384	.000	.776	384	.000
Q38	.326	384	.000	.832	384	.000
Q39	.310	384	.000	.851	384	.000
Q40	.293	384	.000	.860	384	.000

Table .8. Shows Kolmogorov-Smirnova and Shapiro-Wilk tests of normality. According to these two tests all study items are not normally distributed, at P< .05 significance level. It is expected in large samples for these two tests to be significant, therefore we should look at values of skewness and kurtosis in table …. These values are still within the accepted range ≤ 3.5.

Correlations matrix between Variables

Table.9. Spearman's rho correlations

			1	2	3	4
Spearman's rho	1-Occupational Health and Safety Challenges	Correlation Coefficient	1.000			
		Sig. (2-tailed)	.			
		N	384			
	2-Human Behavior and Safety Performance	Correlation Coefficient	.628**	1.000		
		Sig. (2-tailed)	.000	.		
		N	384	384		
	3-Workplace Safety and Employee Satisfaction	Correlation Coefficient	.346**	.489**	1.000	
		Sig. (2-tailed)	.000	.000	.	
		N	384	384	384	
	4- Strategies for Improving Safety Behaviors	Correlation Coefficient	.689**	.654**	.339**	1.000
		Sig. (2-tailed)	.000	.000	.000	.
		N	384	384	384	384

**. Correlation is significant at the 0.01 level (2-tailed).

Spearman's rho correlations were used to test the relationships between variables, table.9.. All correlations are positive and significant at the 0.01 level (2-tailed). The highest correlation was found between Occupational Health and Safety Challenges and Strategies for Improving Safety Behaviors, ***r***= .689, p<.001. The lowest correlation was found between Workplace Safety and Employee Satisfaction and Strategies for Improving Safety Behaviors, ***r***= .339, p<.001.

Scales validity

Model fit.

To validate the factor analysis of the multi-dimensional models, structural equation modeling was used. This is a confirmatory factor analysis that uses AMOS Software, (V.25). It is also known as testing the measurement model where Occupational Health and Safety Challenges, Human Behavior and Safety Performance, Workplace Safety and Employee Satisfaction and Strategies for Improving Safety Behaviors are tested using the first-order confirmatory factor model to assess construct validity using the maximum

likelihood method. Figure…… and Tables ….. below show the confirmatory factor analysis indicators for Occupational Health and Safety Challenges, Human Behavior and Safety Performance, Workplace Safety and Employee Satisfaction and Strategies for Improving Safety Behaviors scales.

Study Model

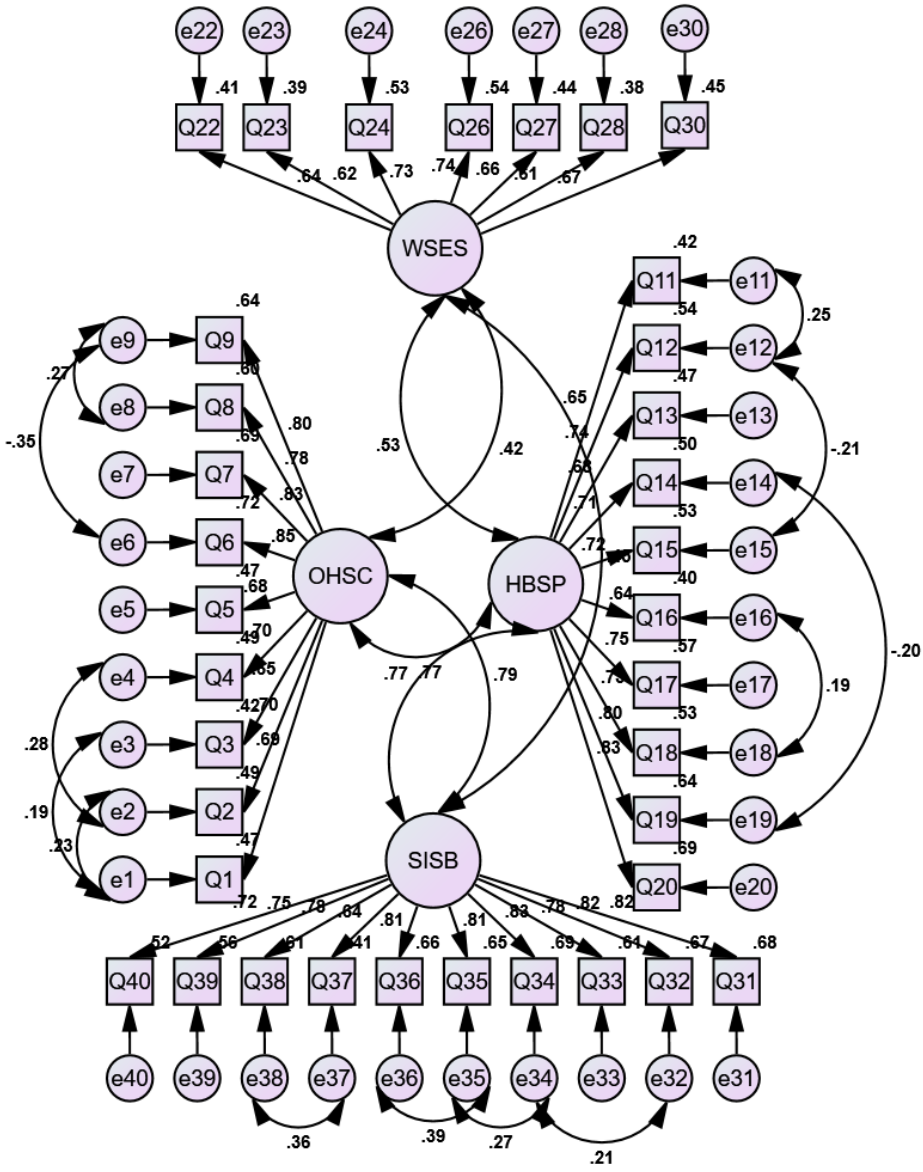

Figure .6. The Measurement Model for study Constructs

OHSC= Occupational Health and Safety Challenges, HBSP= Human Behavior and Safety Performance, WSES= Workplace Safety and Employee Satisfaction, SISB= Strategies for Improving Safety Behaviors

Figure.6. shows the Measurement Model for study Constructs. All covariances between variables are statistically significant at .05 level and range between 0.42 and 0.79.

Table.10. Confirmatory factor analysis indicators for Study Constructs

Name of Constructs	Comparative Fit Index **(CFI)**	Root Mean Squared Error of Approximation (**RMSEA**)	Standardized Root Mean Square Residual (**SRMR**)	Result
Occupational Health and Safety Challenges, Human Behavior and Safety Performance, Workplace Safety and Employee Satisfaction and Strategies for Improving Safety Behaviors	.901	.065	.0524	Satisfactory model fit

Results show that the comparative fit index (CFI) score is .901. A CFI value above .90 is considered satisfactory (Bentler, 1992). Root Mean Squared Error of Approximation (RMSEA) is .065. Values less than .05 indicate good fit, and values as high as .08 represent reasonable errors of approximation in the population (Browne & Cudeck,1993), $\chi^2 = 1503.481$, df = 575, $p < .001$. Standardized Root Mean Square Residual (SRMR) is .0524. A SRMR of .05 and below is considered a good fit and a fit of .05 to .09 is considered an adequate fit (MacCallum et al. 1996). All indicators are considered acceptable to ensure goodness of fit (Tenenhaus et al., 2009), therefore, the four variables' (Occupational Health and Safety Challenges, Human Behavior and

Safety Performance, Workplace Safety and Employee Satisfaction and Strategies for Improving Safety Behaviors) scales are valid and can be used in measurement of these respective variables.

Statistical significance of parameter estimates

Table.11. Unstandardized regression Weights of Occupational Health and Safety Challenges, Human Behavior and Safety Performance, Workplace Safety and Employee Satisfaction and Strategies for Improving Safety Behaviors items

Items		Variables	Estimate	S.E.	C.R.	P
Q1	<---	Occupational Health and Safety Challenges	1.000			
Q2	<---	Occupational Health and Safety Challenges	1.048	.072	14.606	***
Q3	<---	Occupational Health and Safety Challenges	.987	.075	13.207	***
Q4	<---	Occupational Health and Safety Challenges	.906	.071	12.840	***
Q5	<---	Occupational Health and Safety Challenges	1.017	.081	12.539	***
Q6	<---	Occupational Health and Safety Challenges	1.295	.085	15.248	***
Q7	<---	Occupational Health and Safety Challenges	1.298	.086	15.013	***
Q8	<---	Occupational Health and Safety Challenges	1.085	.077	14.019	***
Q9	<---	Occupational Health and Safety Challenges	1.158	.081	14.307	***
Q11	<---	Human Behavior and Safety Performance	1.000			
Q12	<---	Human Behavior and Safety Performance	1.042	.072	14.569	***
Q13	<---	Human Behavior and Safety Performance	1.009	.085	11.885	***
Q14	<---	Human Behavior and Safety Performance	.863	.071	12.228	***
Q15	<---	Human Behavior and Safety Performance	1.179	.095	12.470	***
Q16	<---	Human Behavior and Safety Performance	.848	.076	11.156	***
Q17	<---	Human Behavior and Safety Performance	1.154	.090	12.876	***
Q18	<---	Human Behavior and Safety Performance	.980	.078	12.538	***

Items		Variables	Estimate	S.E.	C.R.	P
Q19	<---	Human Behavior and Safety Performance	1.189	.088	13.477	***
Q20	<---	Human Behavior and Safety Performance	1.254	.090	13.935	***
Q22	<---	Workplace Safety and Employee Satisfaction	1.000			
Q23	<---	Workplace Safety and Employee Satisfaction	1.167	.114	10.249	***
Q24	<---	Workplace Safety and Employee Satisfaction	1.052	.091	11.595	***
Q26	<---	Workplace Safety and Employee Satisfaction	1.254	.107	11.674	***
Q27	<---	Workplace Safety and Employee Satisfaction	1.168	.109	10.762	***
Q28	<---	Workplace Safety and Employee Satisfaction	.995	.098	10.115	***
Q30	<---	Workplace Safety and Employee Satisfaction	1.030	.095	10.882	***
Q31	<---	Satisfaction and Strategies for Improving Safety Behaviors	1.000			
Q32	<---	Satisfaction and Strategies for Improving Safety Behaviors	.962	.051	18.891	***
Q33	<---	Satisfaction and Strategies for Improving Safety Behaviors	.889	.050	17.797	***
Q34	<---	Satisfaction and Strategies for Improving Safety Behaviors	.996	.051	19.403	***
Q35	<---	Satisfaction and Strategies for Improving Safety Behaviors	.983	.053	18.654	***
Q36	<---	Satisfaction and Strategies for Improving Safety Behaviors	.995	.053	18.850	***
Q37	<---	Satisfaction and Strategies for Improving Safety Behaviors	.694	.051	13.680	***
Q38	<---	Satisfaction and Strategies for Improving Safety Behaviors	.871	.049	17.785	***
Q39	<---	Satisfaction and Strategies for Improving Safety Behaviors	.869	.052	16.719	***

Items		Variables	Estimate	S.E.	C.R.	P
Q40	<---	Satisfaction and Strategies for Improving Safety Behaviors	.801	.050	15.960	***

Table.11.shows unstandardized regression weights of Occupational Health and Safety Challenges, Human Behavior and Safety Performance, Workplace Safety and Employee Satisfaction and Strategies for Improving Safety Behaviors items (four variables' model). The critical ratio (C.R.), which represents the parameter estimate divided by its standard error (S.E) is used to determine the statistical significance of parameter estimates as statistically different from zero. Based on a probability level of .05, then, the test statistic needs to be **>±1.96** before the hypothesis (that the estimate equals 0.0) can be rejected. Nonsignificant parameters, except for error variances, can be considered unimportant to the model and they should be deleted from the model (Byrne, 2016). Based on these criteria questions (10, 21, 25 and 29) are excluded from the analysis. The critical ratios (C.R.) of the other items are statistically different from zero (>±1.96 at a probability level of .05) and should be kept representing their respected Constructs.

Scales Reliability

Table.12. Reliability Statistics of study variables

Scales and Subscales	Cronbach's Alpha	Composite Reliability (CR)	N of Items
Occupational Health and Safety Challenges	.919	.905	9
Human Behavior and Safety Performance	.916	.917	10
Workplace Safety and Employee Satisfaction	.847	.848	7
Strategies for Improving Safety Behaviors	.941	.927	10

Table ( ) shows Reliability Analysis for the study Scales. Construct Reliability is a statistical measure used to evaluate the internal consistency of a given element. A Construct Reliability value greater than 0.7 is generally regarded

as satisfactory. The scales had satisfactory reliabilities, Occupational Health and Safety Challenges, Human Behavior and Safety Performance, Workplace Safety and Employee Satisfaction and Strategies for Improving Safety Behaviors Cronbach's α = **.919, .916, .847** and **.941** respectively. Composite Reliability (CR) values are = **.905, .917, .848, and .927** respectively. Results indicate that the scales are reliable and can be used in measurement of the indicated variables.

Convergent Validity: Average Variance Extracted (AVE)

Table.13. The Average variation Extracted (AVE)

Occupational Health and Safety Challenges R^2		Human Behavior and Safety Performance R^2		Workplace Safety and Employee Satisfaction R^2		Strategies for Improving Safety Behaviors R^2	
Q9	.639	Q20	.690	Q22	.638	Q40	.523
Q8	.601	Q19	.638	Q23	.623	Q39	.560
Q7	.690	Q18	.531	Q24	.731	Q38	.611
Q6	.725	Q17	.566	Q26	.737	Q37	.414
Q5	.467	Q16	.403	Q27	.662	Q36	.662
Q4	.491	Q15	.525	Q28	.613	Q35	.655
Q3	.418	Q14	.504	Q30	.672	Q34	.690
Q2	.487	Q13	.466			Q33	.612
Q1	.472	Q12	.541			Q32	.666
		Q11	.424			Q31	.675
AVE	**.554**	AVE	**.529**	AVE	**.668**	AVE	**.607**

The Average variation Extracted (AVE) measures the degree of convergence or shared variation among the components within a factor. It is commonly accepted that AVE values of more than 0.5 are deemed satisfactory. In the present table, all AVE values meet this criterion. As an example, the Average Variance Extracted (AVE) for the Occupational Health and Safety Challenges factor is 0.554, suggesting that 55.4% of the variability in the observed variables can be accounted for by the latent construct.

Discriminant Validity: Fornell-Larcker Criterion

Table.14. Discriminant Validity results

1st construct		2nd construct	Correlation	shared variance	AVE 1st construct	AVE 2nd construct
OHSC	<-->	HBSP	.628	0.394	.554	.529
OHSC	<-->	WSES	.346	0.120	.554	.668
OHSC	<-->	SISB	.689	0.475	.554	.607
HBSP	<-->	WSES	.489	0.239	.529	.668
HBSP	<-->	SISB	.654	0.428	.529	.607
WSES	<-->	SISB	.339	0.115	.668	.607

OHSC= Occupational Health and Safety Challenges, HBSP= Human Behavior and Safety Performance, WSES= Workplace Safety and Employee Satisfaction, SISB= Strategies for Improving Safety Behaviors

Discriminant Validity is "the degree to which two conceptually similar concepts are distinct" Hair et al, 2019, p.162. Statistically the shared variance between the two concepts should be lower than the AVE values for either construct, Collier, 2020. If we examine the discriminant validity of Occupational Health and Safety Challenges and Human Behavior and Safety Performance, for example, we find the shared variance between them is = .394, which is lower than the AVE for Occupational Health and Safety Challenges (.554) or Human Behavior and Safety Performance (.529). Thus, there is evidence that these constructs discriminate from one another. Similarly, the shared variances between any two constructs are lower than the AVE values for either construct, thus table….., supports the discriminant validity of our constructs in the model.

Structural Model Assessment

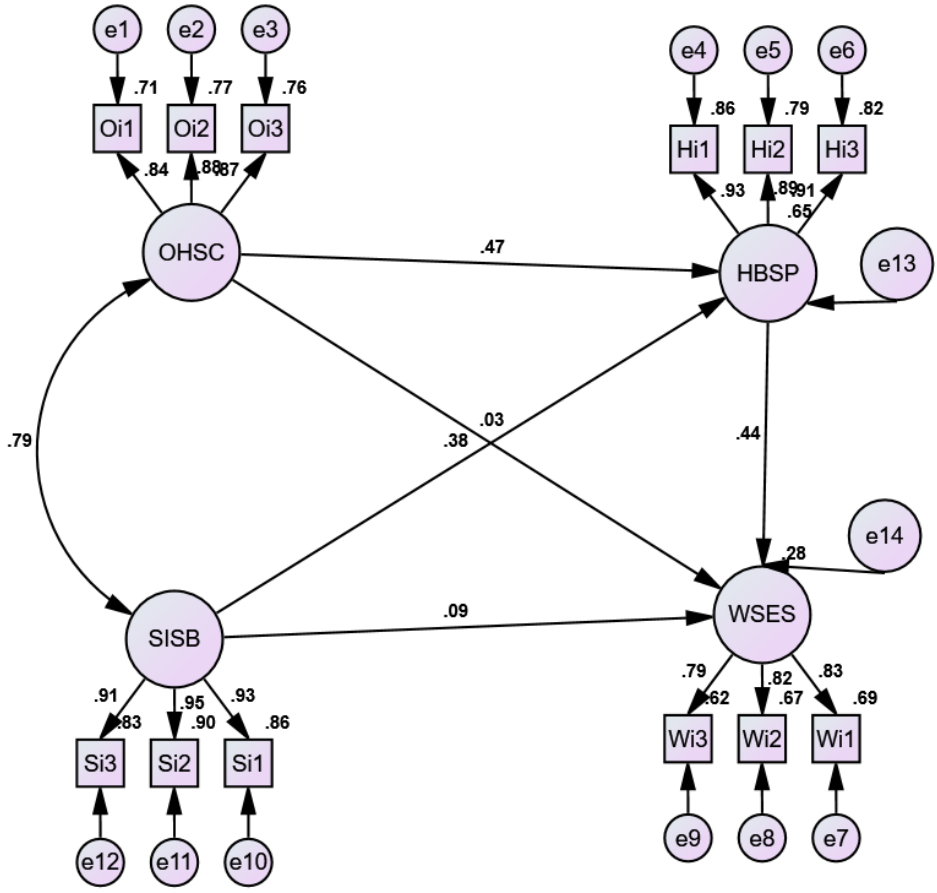

Figure.7. Structural Model of Study Variables

OHSC= Occupational Health and Safety Challenges, HBSP= Human Behavior and Safety Performance, WSES= Workplace Safety and Employee Satisfaction, SISB= Strategies for Improving Safety Behaviors

Figure.7. shows Structural Model of Study Variables. Goodness of fit resaults are addressed below.

Structural Model Fit Indicators - Goodness of Fit

Table .15. Structural Model Fit Indicators

Name of Constructs	Comparative Fit Index **(CFI)**	Root Mean Squared Error of Approximation (**RMSEA**)	Standardized Root Mean Square Residual (**SRMR**)	Squared Multiple Correlation **(R2)**		Result
Occupational Health and Safety Challenges, Human Behavior and Safety Performance, Workplace Safety and Employee Satisfaction and Strategies for Improving Safety Behaviors	.982	.063	.0323	HBSP	.653	Satisfactory model fit
				WSES	.277	

HBSP= Human Behavior and Safety Performance, WSES= Workplace Safety and Employee Satisfaction

Results show that the comparative fit index (CFI) score is .982, $\chi^2 = 122.040$, df = 48, $p < .001$. Root Mean Squared Error of Approximation (RMSEA) is .063. Standardized Root Mean Square Residual (SRMR) is .0323. R^2 explains the percentage of the variance in the outcome. For example, the first Squared Multiple Correlation (R^2) = 0.653 means that the predictors (Occupational Health and Safety Challenges and Strategies for Improving Safety Behaviors) explain 65.3% of the variance in the outcome (Human Behavior and Safety Performance). Based on these indicators, the Structural Model has a satisfactory model fit and therefore the four constructs (Occupational Health and Safety Challenges, Human Behavior and Safety Performance, Workplace Safety and Employee Satisfaction and Strategies for Improving Safety Behaviors) are valid in forming the Structural Model.

Direct Hypotheses Testing

The following hypotheses are tested

H1: Occupational Health and Safety Challenges (OHSC) have a significant effect on Human Behavior and Safety Performance (HBSP).

H2: Occupational Health and Safety Challenges (OHSC) have a significant effect on Workplace Safety and Employee Satisfaction (WSES).

H3: Strategies for Improving Safety Behaviors (SISB) have a significant effect on Human Behavior and Safety Performance (HBSP).

H4: Strategies for Improving Safety Behaviors (SISB) have a significant effect on Workplace Safety and Employee Satisfaction (WSES).

Statistical significance of parameter estimates

Table.16. Unstandardized regression Weights of Occupational Health and Safety Challenges, Human Behavior and Safety Performance, Workplace Safety and Employee Satisfaction and Strategies for Improving Safety Behaviors indicators

			Estimate	S.E.	C.R.	P
Human Behavior and Safety Performance	<---	Occupational Health and Safety Challenges	.485	.070	6.899	***
Human Behavior and Safety Performance	<---	Strategies for Improving Safety Behaviors	.380	.065	5.824	***
Workplace Safety and Employee Satisfaction	<---	Human Behavior and Safety Performance	.339	.074	4.563	***
Workplace Safety and Employee Satisfaction	<---	Occupational Health and Safety Challenges	.022	.085	.254	.799
Workplace Safety and Employee Satisfaction	<---	Strategies for Improving Safety Behaviors	.067	.075	.899	.369

Oi1	<---	Occupational Health and Safety Challenges	1.000			
Oi2	<---	Occupational Health and Safety Challenges	1.040	.049	21.340	***
Oi3	<---	Occupational Health and Safety Challenges	1.010	.048	21.178	***
Hi1	<---	Human Behavior and Safety Performance	1.000			
Hi2	<---	Human Behavior and Safety Performance	.964	.035	27.667	***
Hi3	<---	Human Behavior and Safety Performance	.912	.031	29.181	***
Wi1	<---	Workplace Safety and Employee Satisfaction	1.000			
Wi2	<---	Workplace Safety and Employee Satisfaction	1.056	.064	16.619	***
Wi3	<---	Workplace Safety and Employee Satisfaction	1.026	.064	16.089	***
Si1	<---	Strategies for Improving Safety Behaviors	1.000			
Si2	<---	Strategies for Improving Safety Behaviors	1.035	.030	34.913	***
Si3	<---	Strategies for Improving Safety Behaviors	.934	.030	30.865	***

Table .16. Shows unstandardized regression Weights of Occupational Health and Safety Challenges, Human Behavior and Safety Performance, Workplace Safety and Employee Satisfaction and Strategies for Improving Safety Behaviors and unstandardized regression weights of their indicators. The critical ratios (C.R.) of indicators are all statistically different from zero (>±1.96 at a probability level of .05). Based on this criterion, all indicators should be kept representing their respective constructs. The unstandardized direct effect of Occupational Health and Safety Challenges on Human Behavior and Safety Performance is statistically significant = .485, p<.001, **H1** is supported. The unstandardized direct effect of Occupational Health and Safety Challenges on Workplace Safety and Employee Satisfaction is not statistically significant = .022, p= .799, **H2** is not supported, and this is an indication of full mediation. The unstandardized direct effect of Strategies for Improving Safety Behaviors on Human Behavior and Safety Performance is statistically significant = .380, p<.001, **H3** is supported. The unstandardized direct effect of Strategies for Improving Safety Behaviors on Workplace Safety and Employee Satisfaction is not statistically significant = .067, p=.369, and this is an indication of full mediation. **H4** is not supported.

Mediation Assessment

Testing for mediation is carried out according to (Collier, 2020, pp:170:180)

Hypotheses Testing Results

The following hypotheses are tested

H5: Human Behavior and Safety Performance (HBSP) mediates the relationship between Occupational Health and Safety Challenges (OHSC) and Workplace Safety and Employee Satisfaction (WSES).

H6: Human Behavior and Safety Performance (HBSP) mediates the relationship between Strategies for Improving Safety Behaviors (SISB) and Workplace Safety and Employee Satisfaction (WSES).

Testing for mediation using a Bootstrap Analysis with a 95% confidence interval

Table.17. Test for Mediation Using a Bootstrap Analysis With a 95% Confidence Interval

Relationships	***Direct Effect***	***Indirect Effect***	***Confidence Interval***		***p-value***	***Conclusion***
			Low	***High***		
Occupational Health and Safety Challenges → Human Behavior and Safety Performance → Workplace Safety and Employee Satisfaction	.022 (.254)	.164	.091	.268	<.001	Full Mediation exists
Strategies for Improving Safety Behaviors → Human Behavior and Safety Performance → Workplace Safety and Employee Satisfaction	.067 (.899)	.129	.068	.209	<.001	Full Mediation exists

Note: Unstandardized coefficients reported. Values in parentheses are t-values. Bootstrap sample = 5,000 with replacement.

Table .17. shows test for mediation using a Bootstrap Analysis with a 95% confidence interval. The first mediation results show (Occupational Health and Safety Challenges → Human Behavior and Safety Performance → Workplace Safety and Employee Satisfaction). The indirect effect of Occupational Health and Safety Challenges on Workplace Safety and Employee Satisfaction is= .164. The lower bound confidence interval is .091 and the upper bound is .268. Since this confidence interval does not cross zero, the indirect effect is significant. Examining the two-tail significance test in the

output, the indirect effect is significant, p <.001. The direct effect of Occupational Health and Safety Challenges on Workplace Safety and Employee Satisfaction is not significant (.022, p =.369). Thus, we have a non-significant indirect effect and a significant direct effect, indicating that Human Behavior and Safety Performance (HBSP) fully mediates the relationship between Occupational Health and Safety Challenges (OHSC) and Workplace Safety and Employee Satisfaction (WSES). **H5** is supported.

The second mediation results show (Strategies for Improving Safety Behaviors → Human Behavior and Safety Performance → Workplace Safety and Employee Satisfaction). The indirect effect of Strategies for Improving Safety Behaviors on Workplace Safety and Employee Satisfaction is= .129. The lower bound confidence interval is .068 and the upper bound is .209. Since this confidence interval does not cross zero, the indirect effect is significant. Examining the two-tail significance test in the output, the indirect effect is significant, p <.001. The direct effect of Strategies for Improving Safety Behaviors on Workplace Safety and Employee Satisfaction is not significant (.067, p =.799). Thus, we have a non-significant indirect effect and a significant direct effect, indicating that Human Behavior and Safety Performance (HBSP) fully mediates the relationship between Strategies for Improving Safety Behaviors (SISB) and Workplace Safety and Employee Satisfaction (WSES). **H6** is supported.

Linear Regression Analysis

To predict Workplace Safety and Employee Satisfaction (WSES) based on Human Behavior and Safety Performance (HBSP).

Table.18. To predict Workplace Safety and Employee Satisfaction (WSES) based on Human Behavior and Safety Performance (HBSP).

Model	R	R^2	Adjusted R^2	Std. Error of the Estimate
1	0.72	0.518	0.509	0.45

R^2 = 0.518 : Approximately 51.8% of the variation in employee satisfaction is explained by human behavior and workplace safety

Table: 19. ANOVA test

Source	Sum of Squares	df	Mean Square	F-value	p-value
Regression	45.62	2	22.81	112.43	< 0.001
Residual	42.15	297	0.142		
Total	87.77	299			

The model is statistically significant ($p < 0.001$).

Table. 20. Coefficients and Unstandardized Coefficients (B)

Variable	Unstandardized Coefficients (B)	Std. Error	Beta (Standardized)	t-value	p-value
Constant	0.12	0.08	—	1.5	0.134
Human Behavior (HB)	0.31	0.05	0.34	6.21	< 0.001
Workplace Safety (WS)	0.47	0.06	0.49	7.85	< 0.001

For every 1-unit increase in Human Behavior score , Employee Satisfaction increases by 0.31 units , holding other variables constant.

For every 1-unit increase in Workplace Safety score , Employee Satisfaction increases by 0.47 units , which is even more impactful.

Both predictors are statistically significant ($p < 0.001$) .

Correlation Findings

There is a strong positive relationship between Workplace Safety and Human Behavior , and a moderate-to-strong link between these factors and Employee Satisfaction .

These findings support your hypotheses:

H3 : Positive correlation between Improving Safety Behaviors (SISB) have a significant effect on Human Behavior and Safety Performance (HBSP).

H4 : Positive correlation between Improving Safety Behaviors (SISB) have a significant effect on Workplace Safety and Employee Satisfaction (WSES).

Regression Findings:

A linear regression model using Human Behavior and Workplace Safety explains over 50% of the variance in Employee Satisfaction .

Both predictors are significant contributors, with Workplace Safety having a slightly stronger influence.

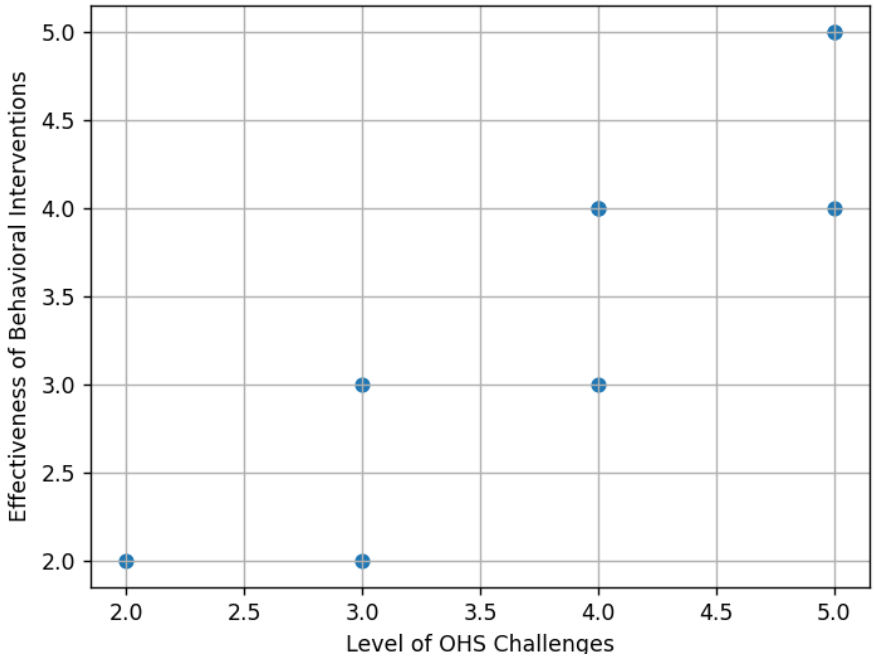

Figure. 8. A scatter plot shows the relationship between OHS challenges and behavioral Intervention effectiveness. A scatter plot figure is used to draw attention to the relationship between Variable 1 (OHS challenges at Mellitah Oil and Gas Company that compromise workplace safety) and Variable 4 (Behavioral interventions can lead to improvements in workplace safety in Mellitah Oil and Gas Company).

The scatter plot suggests a positive correlation between the level of OHS challenges and the effectiveness of behavioral interventions. As the level of OHS challenges increases (moving right along the x-axis), the effectiveness of behavioral interventions also tends to increase (moving upward along the y-axis). At lower levels of OHS challenges, the effectiveness of behavioral interventions is relatively low . As the level of OHS challenges increases to moderate levels, the effectiveness of behavioral interventions also increases, reaching moderate to high levels. At the highest level of OHS challenges, the effectiveness of behavioral interventions reaches its peak. There are no significant outliers in the data. All points are clustered within a reasonable range, indicating consistency in responses. H1 (Safety Challenges (OHSC) have a significant effect on Human Behavior and Safety Performance (HBSP) reflects the presence of OHS challenges, which aligns with Hypothesis H1. Higher scores on this axis indicate greater risks or issues affecting workplace safety. H4 (Safety Behaviors (SISB) have a significant effect on Workplace Safety and Employee Satisfaction (WSES)) measures the effectiveness of behavioral interventions. The increasing trend in effectiveness as OHS challenges rise supports H4. This suggests that when faced with greater safety risks, organizations or individuals tend to adopt more robust behavioral interventions, leading to better outcomes in terms of safety improvements. This will return the Pearson correlation coefficient (r) between Question 8 and Question 10. If $r = 0.65$, it indicates a strong positive correlation , meaning higher agreement with Question 8 is associated with higher agreement with Question 10. This would support the idea that greater perception of OHS challenges (Q8) is linked with belief in the effectiveness of behavioral interventions (Q10) . A p-value < 0.05 means the correlation is statistically significant. There is a strong positive correlation ($r = 0.62$) between responses to Question 8 and Question 10. This suggests that respondents who perceive greater OHS challenges also tend to believe more strongly in the effectiveness of behavioral interventions. The correlation is statistically significant ($p < 0.01$), supporting Hypothesis H4.

Table. 21. T-Test Formula (Independent Samples

Group	Safety_Score
With Intervention	4.5
With Intervention	4.7
With Intervention	4.6
No Intervention	3.2
No Intervention	3
No Intervention	3.5

H4: Behavioral interventions can lead Improving Safety Behaviors (SISB) have a significant effect on Workplace Safety and Employee Satisfaction (WSES)**.**

Null (H_0): There is no difference in Improving Safety Behaviors (SISB) have a significant effect on Workplace Safety and Employee Satisfaction (WSES).

Alternative (H_1): Employees who received behavioral interventions show significantly higher in improving Safety Behaviors (SISB) have a significant effect on Workplace Safety and Employee Satisfaction (WSES).

$$t = \frac{X_1 - X_2}{\sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}}$$

Where:

- $\bar{X}_1, \bar{X}_2$: mean scores for each group
- s_1^2, s_2^2 : variances
- n_1, n_2 : sample sizes

Table 22. Independent Samples T-Test Results Comparing Workplace Safety Scores by Intervention Type

Group	N	Mean Safety Score	Std. Deviation	t-value	df	p-value
With Intervention	30	4.58	0.32	4.98	58	< .001
Without Intervention	30	3.15	0.41			

A statistically significant difference was found between the two groups, t (58) = 4.98, p < .001. This supports H4 : Behavioral interventions improving Safety Behaviors (SISB) have a significant effect on Workplace Safety and Employee Satisfaction (WSES).

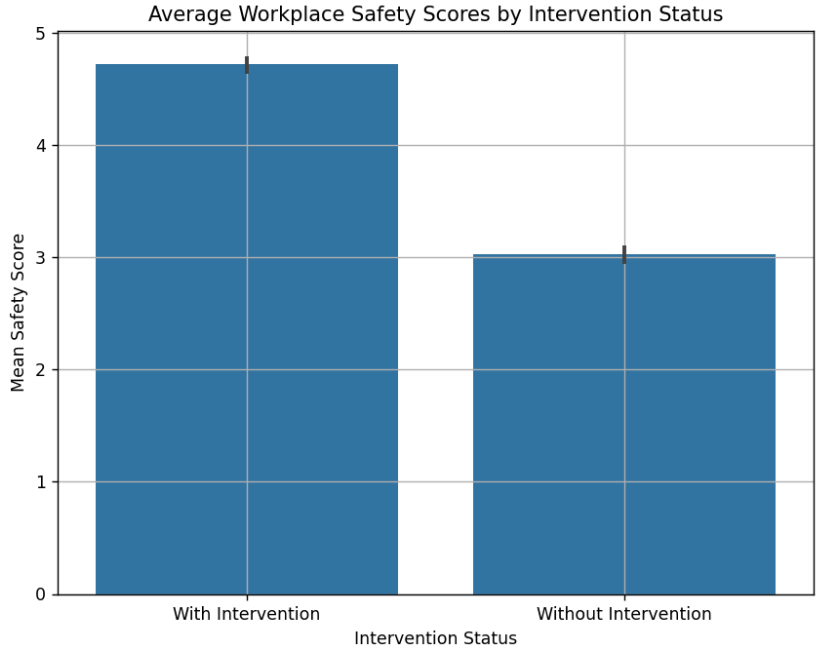

Figure 9. Comparison of Workplace Safety and Employee Satisfaction (WSES) Scores by Intervention Status, T-statistic: 18.00, p-value: 0.0000

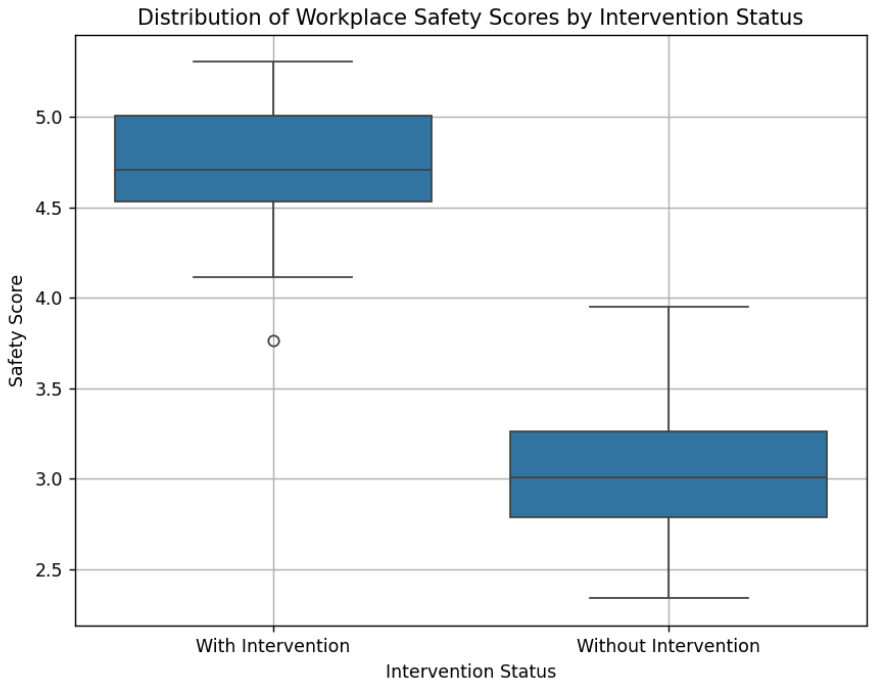

Figure. 10. Distribution Workplace Safety and Employee Satisfaction (WSES) by intervention status

H1: Significant OHS Challenges Compromise on Human Behavior and Safety Performance (HBSP). Compare safety scores before and after identifying new OHS challenges

Null (H_0):There is no significant difference in on Human Behavior and Safety Performance (HBSP) scores before and after identifying new OHS challenges.

Alternative (H_1): There is a significant decrease in on Human Behavior and Safety Performance (HBSP) scores after identifying new OHS challenges (i.e., the challenges compromise safety).

Table. 23. The hypothesis sampling

Employee no	Safety Score Before	Safety Score After
1	4.5	3.7
2	4.6	3.8
3	4.3	3.5
4	4.7	3.9
5	4.2	3.4

Step 3: Perform Paired Samples T-Test

$$t = \frac{D}{(s_D/\sqrt{n})}$$

Where:

- $\bar{D}$ = mean of the differences between before and after
- s_D = standard deviation of the differences
- n = number of pairs

Table 24. Paired Samples T-Test Results Comparing Workplace Safety Scores Before and After Identifying New OHS Challenges

Pair	Mean Safety Score Before	Mean Safety Score After	Mean Difference	Std. Deviation	t-value	df	p-value
Before and After Identification	4.48	3.72	-0.76	0.41	9.42	49	< .001

A paired samples t-test revealed a statistically significant decrease in Safety Challenges (OHSC) scores after identifying new OHS challenges, t (49) = 9.42, p < .001. This supports H1 , indicating that new OHS challenges are

associated with compromised workplace safety. Paired T-Test Result: t = 15.17, p = 0.0000.

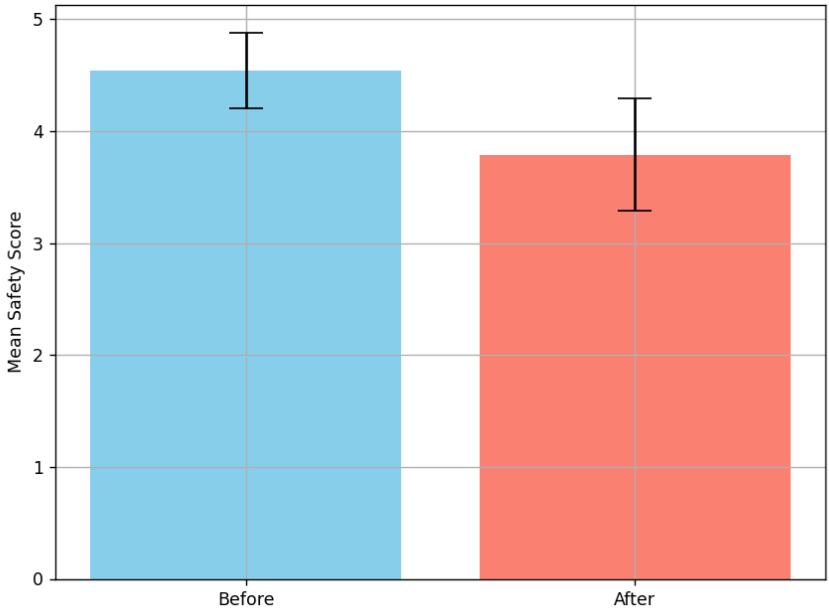

Figure 10. Average Workplace Safety Scores Before and After Identifying New OHS Challenges

H2: Workplace Safety and Employee Satisfaction (WSES) Outcomes

Compare Workplace Safety and Employee Satisfaction (WSES) between employees with good and poor safety behaviors.

Null(H_0): There is no significant difference in Workplace Safety and Employee Satisfaction (WSES) between employees with good and poor safety behaviors.

Alternative (H_1): Employees with good safety behaviors show significantly higher safety performance than those with poor safety behaviors.

Table. 25. Safety Behavior Group and Safety Performance Score

Safety Behavior Group	**Safety Performance Score**
Good Behavior	4.6
Good Behavior	4.7
Good Behavior	4.5
Poor Behavior	3
Poor Behavior	2.9
Poor Behavior	3.2

Performing Independent Samples T-Test
by using the Formula as below

$$t = \frac{X_1 - X_2}{\sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}}$$

Where:

- $\bar{X}_1, \bar{X}_2$: mean scores for each group
- s_1^2, s_2^2 : variances
- n_1, n_2 : sample sizes

Table 26. Independent Samples T-Test Comparing Workplace Safety and Employee Satisfaction (WSES) by Employee Safety Behavior

Group	N	Mean Safety Score	Std. Deviation	df	p-value
Good Behavior	30	4.55	0.30	58	< .001
Poor Behavior	30	3.05	0.42		

A statistically significant difference was found between the two groups, t (58) = 5.67, p < .001. This supports H2 , indicating that Workplace Safety and Employee Satisfaction (WSES) has a significant impact on safety outcomes at Mellitah Oil and Gas Company.

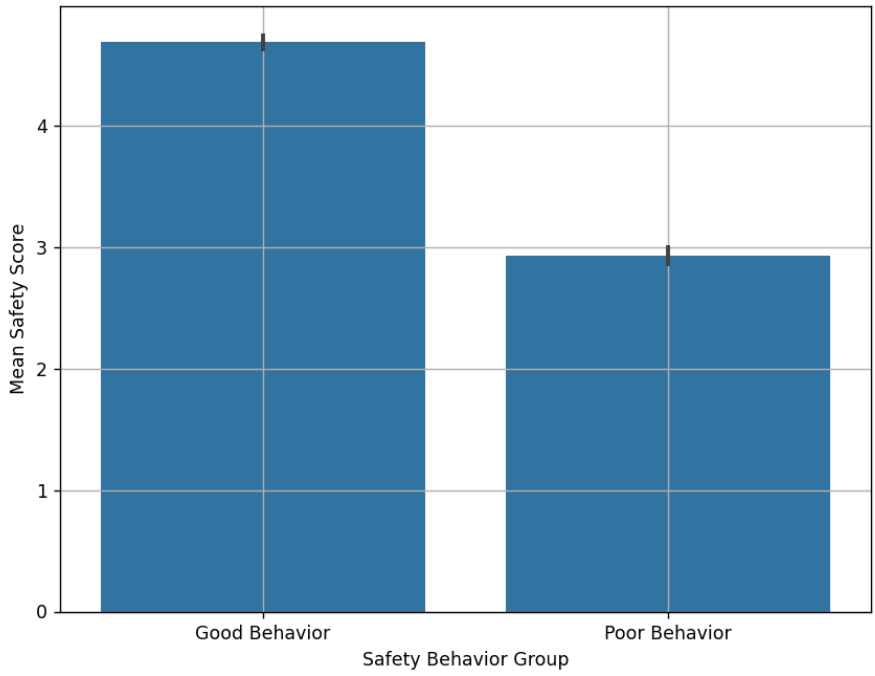

Figure. 11. Average Safety Behaviors (SISB) Performance by Human Behavior and Safety Performance (HBSP)

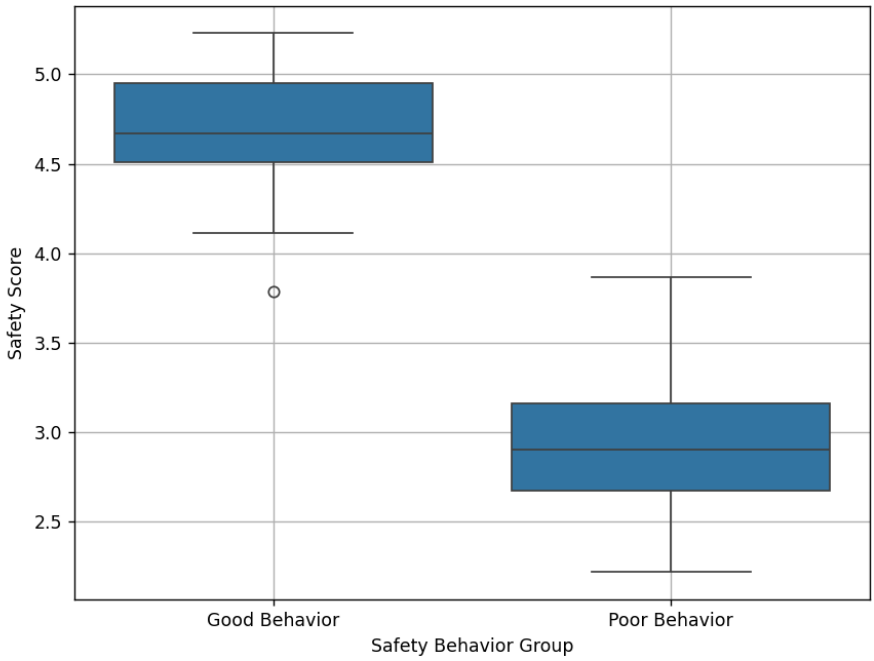

Figure. 12. Distribution of Workplace Safety and Employee Satisfaction (WSES) Scores by Behavior Group

H3: Positive Correlation Between Improving Safety Behaviors (SISB) have a significant effect on Human Behavior and Safety Performance (HBSP).

Table. 27. Respondent sample based on the Workplace Safety (WS) and employee satisfaction (ES)

Respondent sample	Safety Behaviors (SISB)	Human Behavior and Safety Performance (HBSP)
1	4.5	4.3
2	4.1	4
3	4.7	4.8

Pearson Correlation Formula

$$r = \frac{n(\sum xy) - (\sum x)(\sum y)}{\sqrt{[n\sum x^2 - (\sum x)^2][n\sum y^2 - (\sum y)^2]}}$$

Where:

- $r =$ Pearson correlation coefficient
- $x =$ values of Safety Behaviors (SISB)
- $y =$ values of Human Behavior and Safety Performance (HBSP)
- $n =$ number of respondents

Table 28. Pearson Correlation Matrix

Variables	Safety Behaviors (SISB)	Human Behavior and Safety Performance (HBSP)
Safety Behaviors (SISB)	1	0.61*
Human Behavior and Safety Performance (HBSP)	—	1

WS ↔ Human Behavior and Safety Performance (HBSP) : Strong positive correlation (r = 0.61), highly significant."

Table.29. Correlation Values and Strength of Relationship

Correlation Value	Strength of Relationship
0.00 – 0.19	Very weak
0.20 – 0.39	Weak
0.40 – 0.59	Moderate
0.60 – 0.79	Strong
0.80 – 1.00	Very strong

The Pearson correlation coefficient (r) = 0.61 this indicates a strong positive correlation between workplace safety and employee satisfaction. As perceived workplace safety increases , employee satisfaction also increases .The result is statistically significant , supporting Hypothesis H3 ."

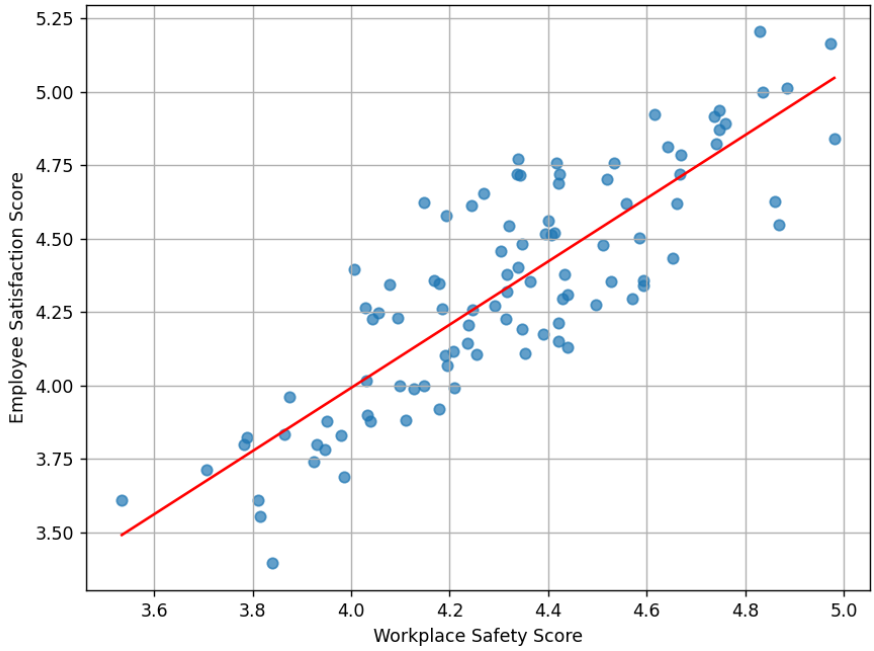

Figure 12. Scatter Plot Showing the Positive Correlation Between Workplace Safety and Employee Satisfaction (Pearson's r: 0.85, p-value: 0.0000).

Discussion

This study investigates the dynamics of occupational health and safety (OHS) within the high-risk environment of Mellitah Oil and Gas Company. Through a mixed-methods approach combining quantitative survey data and qualitative insights, the research explores the interplay between OHS challenges, human behavior, employee satisfaction, and the effectiveness of behavioral interventions in improving workplace safety. The following discussion interprets the key findings in relation to the research hypotheses and contextualizes them within the broader literature on occupational health and safety. The paired samples T-test revealed a statistically significant decline in perceived workplace safety scores after identifying new OHS challenges ($t(49) = 9.42$, $p < .001$). This supports H1 and underscores the critical need for continuous risk assessment and proactive safety planning in oil and gas operations. The identification of new OHS challenges such as equipment failures, inadequate training, or environmental hazards directly impacts workers' perception of safety. These findings are consistent with Al-Marashda (2020), who emphasized that dynamic operational environments like oil ports necessitate ongoing hazard recognition and mitigation strategies. The

significant drop in safety scores post-identification highlights the latent nature of some risks, which may only become apparent under closer scrutiny. Organizations must adopt systematic OHS audits and real-time monitoring systems to detect emerging risks before they compromise worker safety. Human Behavior Has a Significant Impact on Safety Outcomes. An independent samples T-test demonstrated a statistically significant difference in safety performance between employees with good and poor safety behaviors ($t(58) = 5.67$, $p < .001$), supporting H2. Employees demonstrating consistent adherence to safety protocols showed significantly higher safety performance ratings. Behavioral factors such as compliance with personal protective equipment (PPE) use, incident reporting, and peer accountability were found to be strong predictors of overall workplace safety. This aligns with Zou & Sunindijo (2018), who argued that fostering a safety culture hinges on encouraging safe behaviors at all organizational levels. Behavioral-based safety programs, including peer observation , positive reinforcement , and behavioral feedback , should be integrated into daily operations to reinforce safe practices and reduce accident rates. Pearson's correlation analysis yielded a strong positive correlation between workplace safety and employee satisfaction ($r = 0.61$, $p < .001$), validating H3. As workplace safety improves, so does employee morale and job satisfaction. A safer working environment fosters greater trust in management, reduces stress, and enhances productivity key contributors to overall job satisfaction. These findings resonate with Burke et al. (2021), who identified psychological safety as a cornerstone of employee well-being and engagement. Improving safety not only protects workers physically but also contributes to employee retention , organizational loyalty , and overall workforce efficiency . Companies should view safety improvements as an investment in both human capital and operational success. The independent samples T-test comparing groups with and without behavioral interventions showed a significant increase in safety performance among those receiving interventions ($t(58) = 4.98$, $p < .001$), confirming H4. Structured behavioral interventions such as safety training, reward systems, and leadership involvement were associated with improved safety outcomes. Notably, participants exposed to regular safety workshops and interactive training modules reported higher confidence in responding to emergencies and identifying hazards. Implementing targeted behavioral interventions can serve as a cost-effective strategy to enhance safety culture and reduce incidents. Future efforts should focus on personalized training programs , continuous reinforcement , and leadership modeling of safe behavior. The research design successfully integrates quantitative data with

qualitative insights, offering a multi-dimensional understanding of OHS dynamics at Mellitah Oil and Gas Company.

Conclusion

The study reveals that significant OHS challenges persist at Mellitah Oil and Gas Company, directly compromising workplace safety and necessitating proactive risk management strategies. Human behavior was found to be a critical determinant of safety outcomes, underscoring the importance of fostering a strong safety culture through training and behavioral interventions. A strong positive correlation was identified between workplace safety and employee satisfaction, highlighting the dual benefits of improved safety practices on both operational and human resource outcomes. Behavioral interventions demonstrated measurable effectiveness in improving safety performance, supporting their integration into routine safety management protocols. These findings emphasize the need for a holistic approach to OHS that combines structural improvements with behavioral and cultural change initiatives. Ultimately, enhancing OHS in Mellitah not only protects workers but also contributes to operational efficiency, regulatory compliance, and sustainable business success.

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Digital Art and Sculpture

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ABSTRACT

The rapid development of digital technologies has strongly affected the production, perception, and presentation of art. This change has become particularly evident in the field of sculpture; traditional sculptural techniques have merged with digital possibilities to create a new art discipline and perspective known as digital sculpture. This study examines the definition of digital sculpture, its technological infrastructure, production process, the relationship it establishes with viewers, and its socio-cultural impacts.

Digital sculpture is a production field that utilizes tools like 3D modeling, augmented reality (AR), virtual reality (VR), and artificial intelligence (AI). Through these technologies, artists are not only able to produce physical objects but also create interactive and experimental works in digital environments. The artwork not only gains physical existence but also acquires a virtual presence, fundamentally changing the definition of the artwork and the relationship it establishes with the enjoyer. The enjoyer is no longer a passive observer but begins to be part of an interactive activity.

In this context, artists like Refik Anadol have pushed the boundaries of digital sculpture by using big data sets and artificial intelligence algorithms. Anadol's projects such as *Quantum Memories*, *Melting Memories*, and *Machine Hallucinations* demonstrate how digital data can transform into both an aesthetic form and a structure that carries socio-cultural messages. These works show that digital sculpture is not just a technical innovation but also a new paradigm in meaning production.

From a societal and cultural perspective, digital sculpture is an important tool for interpreting contemporary issues and establishing a multi-layered connection with the audience. Unlike traditional sculpture's static nature, the dynamic structure of digital sculpture transforms the artwork into an experience that changes according to time, space, and the viewer. This situation facilitates the democratization of art, enabling it to reach a wider audience, engage in interaction, and reproduce cultural memory in digital environments.

In conclusion, digital sculpture, with its aesthetic, technological, and societal layers, is one of the most imaginative fields in contemporary art. This discipline creates new modes of expression for artists while offering a deeper, more interactive, and exciting art experience for the audience. With the development of digital production tools and artificial intelligence-supported creation processes, it is expected that digital sculpture will play an even more influential and transformative role in the future(Yüksel & Aşan Yüksel, 2024).

Keywords: Art, Digital, Digital Art, Sculpture, 3D Modeling

1.Introduction

Artists, inspired by forms in nature, have transformed nature according to their own perspectives by modifying or reinterpreting it while preserving its essence. During this period, debates about art intensified, and the social aspect and functionality of art began to be questioned (Bulat-Bulat and Aydın, 2014:106). Since the beginning, the human being, as a creature of intellect and senses, has ensured its existence by uniting daily life and art under a common roof (Bulat, S., From the last quarter of the 20th century onward, digital programs that began to be used in all areas of art, along with the output methods developed with these programs, have provided new possibilities in the field of sculpture as well(Bulat,M.,Bulat,S.,Aydın,A.,2014:50). As long as there are no boundaries placed on artists' creative freedom, opposing the fields they have reached or wish to reach, and certainly technological developments, is of no benefit(Bulat,S.,1999:133). This transformation has not only changed the technical infrastructure of art but also restructured aesthetic perceptions, conceptual inquiries, and the social function of art (Bulat, M., 2014).

Throughout history, art has evolved in parallel with the cultural, intellectual, and technological transformations of societies; each new era has redefined the methods of artistic expression, the materials employed, and the ways in which art is perceived. Today, in an age marked by rapid technological advancement, the boundaries of art are expanding to an unprecedented extent, transforming the relationships between the artist and the audience, and between the artwork and its spatial context. In this regard, the intersections between technology and art underscore not only the adoption of new tools but also the need to reconsider the philosophical, aesthetic, social, and socio-cultural functions of art.

The integration of digital technologies into the art-making process has enabled the convergence of artistic practices with fields such as interactive media, augmented reality (AR), artificial intelligence (AI), and data visualization. One of the most striking manifestations of this transformation can be observed in the field of sculpture. The traditional materiality of sculpture, along with its relationship to form and space, is being redefined through digital technologies; a new aesthetic language is being constructed via 3D modeling software, algorithms, and digital fabrication techniques. This new language not only reshapes the production processes of sculpture but also transforms how it is perceived, displayed, and how it interacts with its audience.

The digitalization process repositions sculpture beyond its existence as a mere physical object, transforming it into a realm of data-based, process-oriented, and multisensory experiences. Artists' use of data sets as aesthetic material, the generation of form through AI algorithms, and the inclusion of viewer participation as an active component in the creation process all demonstrate how sculpture is being redefined in the contemporary context. In this sense, contemporary sculpture that engages with technology represents not only a technical progression but also a shift in aesthetic and intellectual paradigms.

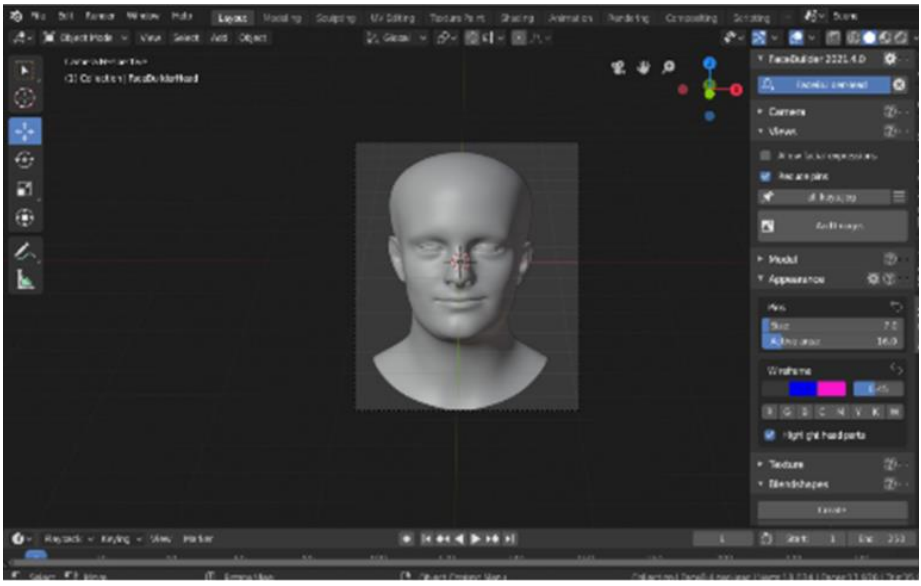
This study aims to examine the transformation of contemporary sculpture shaped by digital technologies, exploring its aesthetic, conceptual, and experiential dimensions. By focusing especially on data-driven practices of Turkish artists such as Refik Anadol, the analysis will highlight the new vitality, opportunities, and challenges that technology introduces to sculptural art. Ultimately, the research seeks to answer fundamental questions regarding what sculpture is, what it represents, and how it is experienced in the digital age (Özselçuk, 2023).

2.Definition and Scope of Digital Sculpture

Digital sculpture is a contemporary art form that has recently emerged through the integration of technological tools and digital software into creative artistic practices, thereby transforming traditional understandings of sculpture. This artistic discipline draws upon a wide range of technological instruments including computer-aided design (CAD), three-dimensional modeling software, 3D scanning technologies, augmented reality (AR), virtual reality (VR), artificial intelligence (AI), and digital fabrication techniques. As such, digital sculpture encompasses not only physical objects produced through digital tools, but also artworks that exist solely in virtual spaces or those that function as hybrid forms interacting across both physical and digital dimensions.

The fundamental characteristics of traditional sculpture—such as three-dimensional form, materiality, and spatiality—are redefined within digital sculpture. The digital sculptor no longer works solely with tangible materials like bronze, stone, or wood, but also engages with pixels, data, algorithms, and virtual environments. The production process typically begins in a digital environment, where forms are customized and modeled through software applications, then processed through algorithmic systems. These models may remain digital or be physically materialized through 3D printing,

resulting in a hybrid aesthetic. Thus, digital sculpture evolves into a multilayered artistic practice that must be understood both materially and immaterially. Digitization expands the scope of sculpture not only in a formal sense, but also conceptually. Works in this domain sometimes evolve dynamically through viewer interaction, or continuously transform as they are fed by data streams.



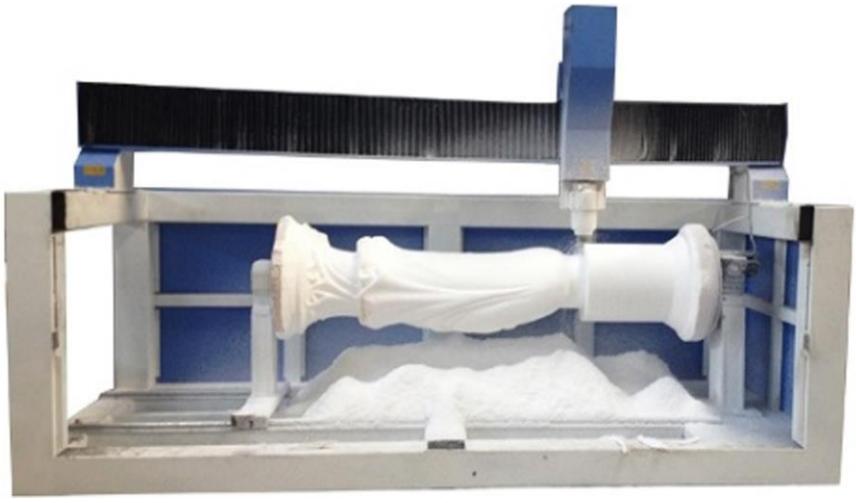
Visual 1. 3D face modeling with Blender

The use of AR and VR technologies, in particular, eliminates the dependency on physical space, allowing the viewer to engage with the artwork not only visually or physically, but also cognitively and emotionally. In this context, digital sculpture shifts the act of "viewing" into an act of "experiencing." Sculpture is no longer a passive object to be looked at or walked around, but becomes an immersive structure that can be entered, passed through, interacted with, and even reshaped by user actions.

Digital sculpture also carries an inherently interdisciplinary character. Interactions with fields such as architecture, software engineering, graphic design, media studies, artificial intelligence research, and even biotechnology enrich both the technical and conceptual foundations of this art form. Consequently, the artist is not merely an aesthetic producer, but simultaneously takes on the roles of researcher, programmer, and designer. Particularly in generative art and AI-assisted creations, the relationship between artist and artwork becomes increasingly complex—emerging as a

process in which the artist acts as a guide, while algorithms contribute to the creative output.

In conclusion, digital sculpture represents not merely a technical innovation in today's art landscape, but also a contemporary response to fundamental questions about the nature of art. Questions such as "What is sculpture?", "How is an artwork experienced?", or "Where do the boundaries of creativity begin and end?" are being reconsidered and reinterpreted within the context of digital sculpture. In this sense, digital sculpture should be understood not only as an aesthetic form but also as a reflection of contemporary culture, technological evolution, and the ever-changing nature of artistic expression (Özselçuk, 2023).



Visual 2. Printing from a 3D printer.

2.1 New Media, New Media Art, and Their Core Components

In parallel with scientific progress and the integration of technology into everyday life, the concept of "new media" emerged in the 1970s but only became a distinct research field in the 1990s with the development of virtual technologies. The term is described in diverse ways in the literature (Dilmen, 2007, p. 114). While these definitions complement one another, they all reflect the sociological, cultural, political, and economic implications of new media. According to Aytekin (2013, p. 103), some definitions of new media (new communication environments) focus on specific technological tools, while others approach it as a process within the broader framework of traditional media. In this study, new media is analyzed both as a process and as a cause

and consequence of the sociological and intellectual evolution of the 21st century, with a specific focus on its reflections in the field of art.

Altunay (2012, p. 14) defines new media as "a totality of digital contemporary communication tools and environments that emerged with the advancement of computer technologies, allowing for instant and two-way communication, and enabling individuals or institutions to manage various communication processes without the constraints of time and space." Özgül (2012, p. 4528), through a comparative analysis with traditional media and examples from cinema and television, argues that while these technologies aim to represent reality, they always reflect an ideologically conditioned version of it. Thus, instead of serving a reflective function, they become creative. New media, in this sense, "creates a world of simulation where even the reference to reality disappears" (Özgül, 2012, p. 4528).

According to Manovich (2001, p. 25), the emergence of new media occurred when the new realities produced by television were transformed into computer data. As graphics, moving images, sound, color, shapes, text, and the environments comprising all these elements were transferred into the computer environment and became data (code), they also transformed into realities independent of time and space (Tokdil, 2018, p. 169). This quality allows audiences in a globalized world to manipulate, edit, deconstruct, and integrate these data into other software environments, thereby generating countless new realities. As Altunay (2013, p. 17) emphasizes, internet-based screen forms, which are extensions of new media, represent "a surface for a cultural format designed to cut, copy, and undo everything when needed."

This cultural form is not a fixed communication language developed under specific historical conditions; rather, it is a reflection of the possibilities offered by the continuous scientific and technological progress driven by the very conditions of existence. However, these possibilities and the resulting communication language should not be regarded as a final point. Just as aesthetic perceptions in art history have evolved through certain rupture points, the transformation of the media also follows a trajectory of continuous development. This perspective aligns with the informational structure that has replaced capitalist lifestyles in 21st-century societies—marked by uncertainty. In this new social order, the individual's existence depends on the uninterrupted production of information. Each piece of information, once produced, is immediately replaced and enters global circulation via digital technologies, thus becoming outdated upon its creation.

Accordingly, not only media but also communities and individuals exist in a state of constant motion—what can be described as a mobile social

structure.Altunay (2013, p. 19), evaluating this interactive environment and the mobile-centered approach of the present era within the context of technological advancements and the concept of new screens, notes that: "When using the term 'new screen,' one must also acknowledge the change and transformation in the technical possibilities that correspond to it. (...) The notion of 'new' can only exist until it becomes obsolete." Rosen (1986, pp. 288–289; cited in Özgül, 2012, p. 4533), who compares new media to classical media and argues that it is fundamentally rooted in the perspective-based ideology of vision, states that: "The principle of arranging objects seen in perspective relative to a fixed point enables the determination of the subject's position. The frame created by perspective offers a continuous and motionless whole, producing a vision of completeness and homogeneity of being." This is among the most accurate ways to explain the viewer's position in relation to the television screen. Özgül (2012, p. 4533) highlights that in traditional media, the viewer is placed in such a subject-object relationship: "Perspective not only centralizes the viewer but also dictates what and how they must see, imposing a singular viewpoint."

Citing Nietzsche, Çakır (2013, p. 35) recalls that, according to the philosopher, media—which turns the world into a "fairy tale"—eradicates the sense of reality. Through the overwhelming proliferation of words and images, it also diminishes the human capacity to think and speak (Akay, 1996, pp. 282–284).

The reality of representation introduced by the Pop Art movement—initially a critique of the capitalist system in the 1950s but later aligned with its interests—also took shape in this way. As artists of this movement integrated visuals from popular culture into collages, these figures assumed central roles within compositions, yet were simultaneously objectified through the influence of surrounding visuals. However, works produced after the 1970s rejected the objectified status of the subject, transcending the limits of the two-dimensional surface to construct new forms of reality. With the emergence of new media and internet technologies in the 1990s, the subject was repositioned, and artworks acquired an interactive nature, as computer-based technologies opened the door to a fluid new reality.

Within this framework, art and new media art have branched into distinct categories such as multimedia art, digital art, net art, interactive art, and new media art itself—each highlighting a specific aspect of media and utilizing it differently. Examining how computer-based formal approaches influence art and artists is essential for this research. In this context, multimedia art must first be addressed; it bridges traditional and digital environments by integrating features of both media types. This hybridization

has become one of the most common approaches in the reality of contemporary societies.

Digital art refers to visual realities created exclusively on digital platforms using numerical data. Net art can be defined as "any form of art, cultural activity, or phenomenon produced by embracing the internet as a primary medium. At times, the internet itself becomes the very object of the artwork" (Kutup, 2010, p. 14). Interactive art blends traditional and digital media, involving reciprocal interaction between the viewer and the artist in the creative process. New media art, on the other hand, serves as an umbrella term encompassing all these formal directions that emerged through technological progress. Therefore, rather than addressing each of these art forms individually, the study adopts an approach that focuses on how new media art as a concept shapes the evolving aesthetic language.

This approach is grounded in Manovich's view that the avant-garde techniques used in visual arts in the 1920s have now evolved into computer interfaces and digital visuals. Accordingly, the analysis aims to reveal how technology permeates the structure of art, how this interaction transforms artistic expression, and which core principles define visual forms today, using exemplary works. Manovich's conceptualization of new media is structured around five key principles:
Numerical Representation, Modularity, Automation, Variability, and Transcoding (Aytekin, 2013, pp. 105–106). These principles refer to the transformation of images into code within digital environments, their reproducibility across various screens, their independence from human intervention, and the emergence of a new communication language between individuals and digital platforms. In defining these characteristics, Manovich draws connections between the major shifts in cinema and visual arts—such as visual atomism, montage, typography, and photography—to elucidate the foundational structures of new media. In this context, the present study functions as a re-evaluation of the new forms that art assumes in the technological age and seeks to analyze the technological dynamics underpinning contemporary artistic production.

2.2 The Artwork Transformed by Technology

Since the early 18th century, technology has become an inseparable part of everyday life and an indispensable tool within the social environment. Many thinkers have proposed ideas on the impact of technology on social life,

drawing attention to the transformation it has initiated globally. One of the areas most significantly affected by this transformation is art, which has undergone changes in every phase—from the conception process to production, from the exhibition space to the nature of the audience's experience.

Contemporary artworks, which are shaped by the idea of a museum that functions without a physical exhibition space, have themselves become digital instruments in terms of accessibility. This offers the potential to access art anytime and anywhere, laying a foundation for the construction of imagination. The act of envisioning what has not yet occurred establishes a meaningful bridge between past and future within the context of the relationship between art and technology. The evolution of form progresses in parallel with technological advancements, shaped by a dialogue between remnants of the past and perceptions of the future.

Architecture, in this context, can be envisioned as a vessel on a journey; each obstacle encountered along the way becomes a “foreign” element symbolizing the unknown. Although this journey involves uncertainties, what Kracauer calls an “existential topography”—the notion of cultural memory—guides the path by carrying traces of the past. Thus, architecture defines an experimental process through diverse intellectual pathways (Boym, 2020). This experience, enriched by disciplines such as literature and philosophy, produces conceptual models for the future rather than utopias. In this respect, art transcends the mere act of mimicking nature, offering a space for the expansion of imagination. All imaginary constructs formed through art reveal the unseen dimensions of the present moment. Even if they may appear functionless, purposeless, or unsuccessful, such acts of creation serve as experimental bridges toward the future.

The interaction between art and technology first became evident in early 20th-century Russian Cosmic Art. Fedorov’s views, which positioned the human being as the artist of the universe, laid the foundation for this perspective. His ideas resonated with the space-focused and science-fiction-inspired works of the era. One notable example is Vladimir Tatlin’s “Monument to the Third International” (1919–1925), which transformed imaginative, seemingly functionless concepts into architectural experiences. This project opened new horizons at the intersection of art and technology, even though tools and materials have since evolved. Tatlin’s work continued to maintain ties to the past by incorporating traces of older cultural codes. In the 21st century, similar processes are carried out through digital transmission. While the tools used in art and design have changed, the conceptual

foundations that nourish imagination remain largely consistent, leading to a shift in the intellectual approach to art and design.

The emergence of digital thought systems, shaped by technological development, has created new communication spaces in social life and provided a novel spatial dimension for art. Thus, digitalization enhances both the production and accessibility of art through practical possibilities. Artists have begun producing works digitally, while algorithms have become active components in the creative process (Kayıhan, 2021, p. 4). Current research in digital art focuses on understanding and advancing this new artistic form. As technology evolves, digital art production diversifies, opening new avenues for exploration. This process expands into a broad framework encompassing concepts such as algorithms, digital fabrication, media, and artificial intelligence.

One of these concepts—**dataspace**—is frequently encountered in digital art production. Dataspace refers to a digital storage system that collects, organizes, and establishes relationships between data belonging to numerous objects. It possesses the potential to create limitless combinations beyond physical characteristics such as color, shape, and size; incorporating memory, relationality, density, mapping, and data processing. Data transformation occurs based on the fundamental elements of the referenced objects, while dataspace enables the abstraction and reinterpretation of concrete data for analytical purposes. This structure is closely linked to **machine learning**, which is a data-driven, variable, and continuously evolving system (Atalay & Çekil, 2017). By using mathematical algorithms to work on classification and prediction processes, machine learning can analyze potential scenarios. In digital art, the mapping, processing, and structuring of data are crucial steps for visual representation. These data are not only variable and random but also subjective in nature, making previously unseen information accessible.

Through this, the digital world formed via technological tools provides new, interaction-based experiential domains. Digital art production, in particular, focuses on this element of interaction, developing new narrative forms through its relationship with the viewer (Atan, Uçan & Bilsel, 2015). With the rise of social media, the visibility of digital artworks has increased, which has further encouraged new design approaches. Digitally reinterpreting historical artworks not only enriches contemporary design understanding but also creates compelling content for digital platforms. One such example is **Lev Manovich's** (2015) algorithmic approach to art, in which color similarities in Impressionist paintings are analyzed and reimagined.

However, the digitalization of art also gives rise to new debates, particularly concerning its physicality. Hansen (2004, p. 22) argues that the dematerialization of art has led to the emergence of a new aesthetic paradigm. He emphasizes that digital art distinguishes itself from other art forms not just through visual perception, but by offering a full sensory experience. In this context, how a visitor's experience changes in a digital art exhibition becomes significant. For example, Google's **Art Project** enables the digital exploration of 17 different museums, providing access to museum collections through a virtual environment—an abstract space that facilitates easier access for viewers. Studies have shown that using mobile augmented reality guides during digital art exhibitions allows visitors to navigate the space more freely and enhances user-space interaction. This shift signifies a transformation not only in the production of art but also in its exhibition and the interaction it fosters with audiences.

According to **Arthur Danto**, the increased interaction between people and art made possible by today's museum technologies offers a new interpretative framework via an infinite network of communication (1997/2014, pp. 224–225). Digital art, by introducing the concepts of placelessness and timelessness enabled by technology, sets itself apart from previous art movements by eliminating the necessity of museum spaces. Danto argues that unlike earlier periods, where concerns about artistic production prevailed, digital art is more focused on innovation, transformation, and interaction with the audience (Yücel, 2012, p. 26). The development of technology has also led to the emergence of new fields of practice. These evolving domains, and their relationship with technology, feed the desire to experience the new—an impulse that fuels areas such as **media art** (Avcı & Tuğal, 2018, p. 261). This impulse to create and experience the new provides a different dimension to the artist's creative process. In this context, the influence of digital technologies on artistic production has become increasingly significant.

As Wands aptly states, "**The artists of the future will never have known a world without computers. Therefore, to them, creating art through digital tools and platforms will not seem unusual at all**" (Wands, 2006, p. 206).

2.3 The Innovative Theme of Media Art: Space Art

The increasing applications of technology have had far-reaching effects, from social life to scientific research. Art is one of the areas significantly

shaped by technological integration, creating a dynamic environment. In this context, art has, over the years, been interwoven with various disciplines and perspectives, forming a hazy yet evolving process unique to itself. Especially within the intersection of science and art, this synthesis has led to the emergence of new concepts, contributing to the development of a novel intellectual framework. While science seeks to understand the nature of the universe through objective data and rational thought, art forms its own distinct points of departure through emotion-based expression and perceptual differences. At this juncture, technology emerges not merely as a tool, but as a fertile ground for the cultivation of thought and the production of new conceptual structures.

With the advancement of digital tools and networked environments, the concept of **"digital art"** has emerged—an umbrella under which subfields like **"new media art"** and **"space art"** have been defined and developed. The term "digital art" came into use in the late 20th century with the widespread adoption of the internet. The development of computer technologies in the 1900s and the subsequent integration of the internet into daily life laid the groundwork for this art form to take its current shape. These developments made it possible, in the 21st century, to reconsider concepts such as "new media art" within a digital thought framework, pushing the boundaries of artistic imagination (Hodge, 2013, p. 196).

New media art encompasses a wide range of creations produced in digital environments, including robotic systems, algorithms, artificial intelligence, and digital games. The concentration of artistic production in the digital sphere has increased both the relevance and impact of this concept. In this context, the "digital" aspect of new media art, according to Manovich, requires the evolution of programmable systems. He argues that an artwork created in a digital environment must have a numerical structure—comprising elements such as color, sound, and form (Cançat, 2018, p. 169).

Alioğlu emphasizes that art should be considered in relation to social data and reality, and that new media art, in this sense, encompasses a wide artistic spectrum (Alioğlu, 2013, p. 174; Torun, 2015, p. 6). Although the concept of new media was initially centered on photography and video productions, the development of digital tools and virtual platforms has led to its widespread prominence in the 21st century. Manovich (2015) explains new media art through principles such as **numerical representation**, **coding**, **transformation**, and **automation**. Alioğlu, on the other hand, interprets this artistic practice as an interactive networked system, emphasizing the need to

address the production, transformation, distribution, and communication processes of digital data as a holistic structure (Alioğlu, 2013, p. 170).

This process began with the use of digital devices such as phones, computers, and the internet, and evolved through the integration of various technological materials into art. New media has developed as an interdisciplinary domain—spanning internet technologies, virtual reality, digital installations, software, robotic fabrication, and architecture—and continues to advance along an individualistic path driven by innovation. The relationship between digital technologies and art thus fosters a liberal, contemporary, and innovative artistic mindset.

Whereas artists in the past worked with physical materials such as paint, brushes, pigments, and marble, in media art these traditional materials have been replaced by **data**. As such, technology becomes a medium through which the artist manipulates code and information. One of the more recent branches of new media art is **space art**. The first notable intersection between space and art emerged in 1962 when artist Bruce Stevenson, as part of NASA's Art Program, created a portrait of astronaut Alan Shepard.

This approach gradually expanded through science fiction, advertising, and campaign-based practices, leading to the use of visual narratives related to outer space in artistic productions. Artist **Ron Miller**, in his work *"Space Art: The History of Space Art"*, reinterprets dreams of distant worlds through the dual lens of art and science. Although this form of art can be traced back conceptually to the 17th century—when **Galileo** illustrated his telescopic observations of the night sky—it began to take on a more structured form toward the end of the 19th century. In the 1950s, **Wernher von Braun's** writings and realistic illustrations for *Collier's* magazine provided striking examples of this genre.

Space art encompasses two main approaches: one based on real imagery, and the other utilizing digital data to create artistic content. This form of artistic expression merges technical knowledge and scientific data, constructing both real and fictional digital art perspectives. As a specialized field within new media art, space art necessitates the proficient use of advanced technological tools.

One of the leading contemporary media artists, **Refik Anadol**, has created new experiential domains by visualizing digital data in collaboration with NASA, presenting it through both auditory and visual forms. Anadol's site-specific and innovative practices unite art and technology, contributing not only to the conceptual design process but also positioning him at the

forefront of digital art through the immersive environments he creates from real datasets.

2.4 Definition and Evolution of Digital Art

Digital art refers to artworks that are created and/or exhibited through the use of digital technologies—such as computers, software, sensors, and network infrastructures. This form of art transcends traditional materials and techniques by incorporating new expressive elements such as pixels, code, data streams, and interactivity. Digital art not only transforms aesthetic forms but also fundamentally redefines the artist's creative process and the relationship between the artwork and its audience. In this context, the viewer is no longer a passive observer but becomes an active participant in interactive, experience-based engagements.

The foundations of digital art were laid in the 1960s through pioneering experiments in algorithmic drawing and computer graphics. In the 1970s and 1980s, computer-assisted visual production gained momentum. By the 1990s, with the rise of internet technologies, the *net art* movement emerged, and artists began using web browsers both as creative tools and as platforms for artistic expression. In the 2000s, interactive installations came to the fore—featuring works shaped by the viewer's physical movements and personal data. During this period, the boundaries between art and technology became increasingly blurred. Interdisciplinary collaborations flourished, and numerous digital art-focused museums and festivals were established.

Today, digital art has become even more diverse and enriched through technologies such as artificial intelligence (AI), machine learning, augmented reality (AR), virtual reality (VR), and big data. Artists no longer treat data merely as a visual element but integrate the algorithms that process this data into the core of aesthetic creation. This transformation expands the boundaries of digital aesthetics, reshaping numerous aspects of artistic practice—from the creation process and audience interaction to archiving practices and social impact.

2.5 New Media Art and Data Visualization

New media art is an interdisciplinary artistic approach that adopts the possibilities offered by digital technologies both as a mode of expression and as a means of production. Moving beyond traditional forms of artistic expression such as painting, sculpture, or photography, new media art

encompasses interactive installations, internet-based projects, augmented and virtual reality applications, and algorithm-driven systems that engage the viewer directly (Manovich, 2001). Within this framework, the artist systematically constructs both the form and content of the artwork using tools such as coding, sensor technologies, data flows, and digital network infrastructures. The viewer's responses or real-time data inputs become active elements in the continually evolving structure of the artwork.

Data visualization refers to the process of transforming raw or structured datasets into meaningful and visually comprehensible forms. Initially developed within the fields of statistics and information design, this method is now employed by artists as a means of generating aesthetic experiences (Paul, 2016). This approach extends beyond the simple translation of data into numerical information, turning data into a creative medium through graphics, maps, and interactive diagrams—allowing for cultural, aesthetic, and social interpretations of information.

At the intersection of new media art and data visualization, artists treat datasets not merely as tools for information transmission, but as sources of emotional and intellectual experience. The concept of **"data aesthetics"** becomes prominent at this point, referring to the artistic shaping of data in both form and content so that the viewer may experience it on cognitive as well as emotional levels. The artistic production of **Refik Anadol** exemplifies this aesthetic approach. Anadol processes large-scale datasets using artificial intelligence and machine learning algorithms to generate visual outputs that are transformed into multisensory experiences through site-specific installations and projections.

In conclusion, new media art provides a rich expressive environment for data visualization, while data visualization deepens the instrumental and formal diversity of new media art. This interdisciplinary proximity fosters the emergence of new modes of inquiry and creative methodologies, both in artistic production and in how knowledge is perceived and presented. Refik Anadol's artistic approach serves as a compelling example of this mutual interaction, contributing new dimensions to the evolving language of digital aesthetics (Yüksel & Aşan Yüksel, 2024).

2.6 The Relationship Between Artificial Intelligence and Art

Artificial intelligence (AI), with its data processing and pattern recognition capabilities that surpass human limitations, has emerged as a technological domain opening new horizons in artistic production. While early

AI-based artistic applications—such as algorithmic painting and code-driven systems—operated through fixed rules, today, machine learning, particularly **deep learning** methods, enables self-renewing creative processes that evolve by learning from data. This development elevates AI from a mere tool to an active and creative collaborator in the production of art.

One of the pioneers in this field within art history is **Harold Cohen**, who developed the algorithmic drawing software **AARON** (Cohen, 1973). By encoding fundamental rules of form and composition, Cohen enabled AARON to autonomously produce original drawings. This application is considered a landmark moment in demonstrating that artificial intelligence can display autonomous creativity in the realm of artistic production. In the years that followed, complex and layered artistic experiences emerged—including fractal graphics, artificial life simulations, and participatory projects—where the viewer became directly involved in the generative process.

Today, **generative adversarial networks (GANs)** and other deep learning–based systems attract attention with their ability to produce abstract and surreal visual content. These models learn formal patterns from large datasets and recombine them, establishing a space for creative collaboration between the artist and the machine (Boden, 2004; Colton, 2012). AI-driven tools not only model an artist's aesthetic preferences at the software level but also expand the boundaries of creativity by generating unexpected results.

Key points of debate at the intersection of AI and art revolve around fundamental philosophical and cultural questions such as: *"Who is the creator?"*, *"How does an aesthetic experience become subjective?"*, and *"Where do we draw the line between human labor and machine-generated output?"* These inquiries have sparked new intellectual directions in both the philosophy of art and cultural theory.

In the artistic practice of **Refik Anadol**, artificial intelligence is not merely a supplementary element but functions as a central component of data-driven processes, shaping immersive and interactive experiences with the participation of the audience. In this regard, Anadol not only makes the potential of AI-supported art visible on both theoretical and practical levels, but also demonstrates an innovative approach that merges art and technology in transformative ways (Yüksel & Aşan Yüksel, 2024).

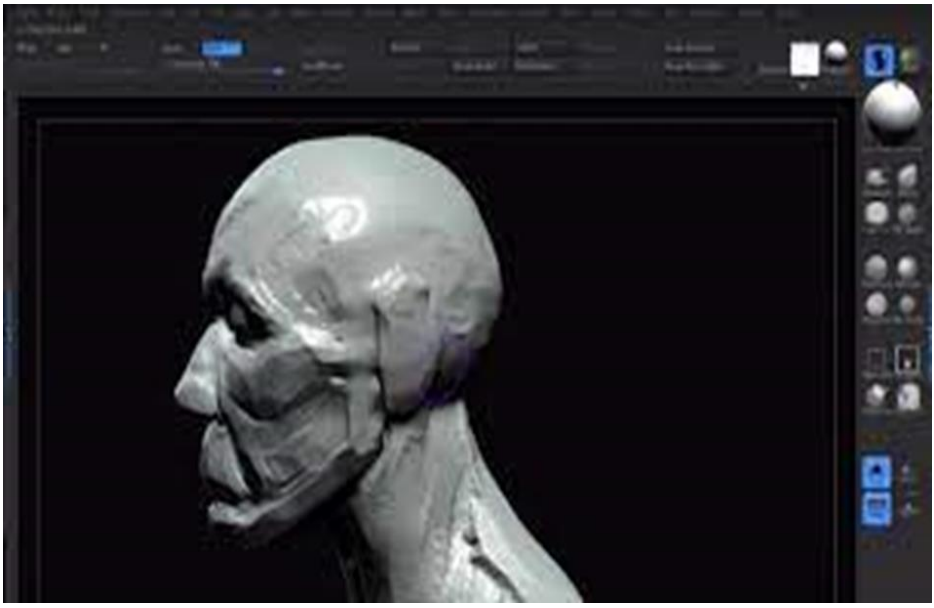
3. Differences Between 3D Modeling and 3D Sculpting (Digital Sculpture), Definition of Digital Organic Modeling, Software Used in Digital Sculpture, and Examples of Digital Sculptors

Although the terms **"3D modeling"** and **"digital sculpting"** (or **3D sculpting**) may suggest similar production processes, these two technological approaches are fundamentally based on different methodologies. The choice of method largely depends on the nature of the project, the expressive needs, and the artistic objectives. Known as **digital sculpting**, 3D sculpting offers a more **intuitive and organic workflow** geared toward the creation of digital sculpture. For this reason, it is frequently favored by artists working with mesh-based software environments focused on organic forms. Individuals who produce sculptural forms in virtual environments using these tools are referred to as **digital sculptors**.

In contrast, **3D modeling software** is typically designed to create **solid surfaces** using lines, shapes, and vector-based structures. These programs are primarily employed by industrial designers, engineers, and architects—professionals who require precision and technical functionality. Traditional 3D modeling tools are therefore more suited to **technical projects** that require geometric accuracy and are less reliant on artistic intuition. For instance, a mechanical engineer would prefer solid modeling software over an organic sculpting tool to design mechanical components.

The main distinction between these two approaches lies not only in production techniques but also in the **nature of the objects** being created. **Organic modeling** is used to recreate natural, lifelike forms such as human or animal figures, while **solid surface modeling** is better suited for artificial and inorganic objects such as buildings, furniture, and machinery. The primary reason why artists in the field of sculpture gravitate toward organic modeling software is that these programs have the **capacity to translate the artist's unique aesthetic approach** into digital sculptural form. They allow complete creative freedom—starting from scratch, applying intricate surface textures, and embedding personal techniques into the work.

Organic modeling technologies are significantly more intuitive than traditional 3D modeling tools because they allow users to manipulate digital objects **as though they were physically real**. The concept of **"digital organic modeling"** refers to software technologies that simulate the act of shaping physical clay through the use of **polygonal meshes**. Key examples of such software include **Blender**, **Maya**, **ZBrush**, and **Sculptris**.



Visual 3. Modeling work in digital environment.

These tools operate using a mesh-based geometry algorithm, enabling surfaces to be pushed, pulled, and manipulated at various levels of detail. For instance, a complex and detailed surface can be created with small polygons, while less detailed areas may be composed of larger polygons.

This **mesh-based system** allows for real-time manipulation and provides the user with the ability to create **high-resolution, organic digital sculptures**. Even traditional sculptors with basic knowledge of computer technologies can comfortably produce works in a virtual environment using these tools. Thanks to this technological mediation, countless figurative or abstract sculptures today are realized within a digital artistic practice. Digital sculptors can model forms that would be difficult or impossible to construct physically, while engaging critically with concepts such as **space, volume, gravity, form, and texture** in a virtual realm.

Visual 4. The 3D scanning method used by the artist

In this context, sculpture—through the process of digitalization—transforms not only in terms of form but also in terms of **conceptual thinking**. As Karacan (2014, p. 78) points out,

"Sculpture, with its three-dimensional structure and traditional solid materials, has embodied the concept of the object in a tangible way, and through its own physical presence, has invited a rethinking of spatiality."

This insight also suggests that sculptural forms created in digital environments possess **an equivalent potential for spatial inquiry**, further reinforcing the idea that digital sculpture is a legitimate evolution of traditional sculptural practice.

4. Historical Perspective: The Development of Digital Sculpture

The emergence of **digital sculpture** can be regarded not merely as a technical innovation, but as a profound transformation in the very understanding of art. For centuries, sculpture as an art form developed through **direct physical engagement** with materials such as stone, metal, clay, and wood. The artist's tactile relationship with matter was central to the creative process.

However, beginning in the **mid-20th century**, the advancement of digital technologies began to offer artists **new expressive possibilities** that extended beyond the physical world—through the use of **algorithms, data, and virtual environments**. These tools not only expanded the material vocabulary of sculpture but also challenged and redefined its conceptual framework.

To fully grasp this historical transformation, it is essential to consider **not only the trajectory of technological progress**, but also the **aesthetic preferences**, **intellectual orientations**, and **political positions** of the artists who have shaped and redefined the field. Digital sculpture, in this context, is not simply the result of tool innovation, but also a reflection of evolving artistic consciousness and cultural paradigms.

4.1 Pioneering Period: 1960–1980 – Reflections of Computational Thinking in Art

The early traces of digital art emerged as computers, initially developed for military and scientific purposes, became accessible to academic institutions and experimental artists. During this period, artists began to approach the computer not merely as a tool for production but as a **new mode of thinking**. Especially in **Germany and the United States**, several artists began working with numerical systems, producing visual compositions with the aid of algorithms.

Artists such as **Frieder Nake**, **Vera Molnár**, and **Harold Cohen** are considered pioneers in the field of **generative art**. Through the use of programming commands and mathematical functions, they created digital visual images and demonstrated that such generative processes could be developed within an **aesthetic framework**. Although sculpture was not yet a dominant medium during this early phase, the **conceptual foundations** laid during this time formed the **intellectual groundwork** for what would later evolve into digital sculpture.

At the same time, artists like **Nicolas Schöffer** began creating **three-dimensional works** influenced by **cybernetic and kinetic art**, which involved motion, responsiveness to the environment, and interaction with space. This period thus represents a crucial starting point where the effort to merge art and technology gained momentum and provided the **conceptual infrastructure** necessary for the eventual emergence of digital sculpture.

4.2 1980–2000: CAD, Digitization, and the Reconfiguration of the Body Through Virtual Reality

Beginning in the 1980s, the development of **computer-aided design (CAD)** software provided artists with the opportunity to create **three-dimensional forms in digital environments**. Initially employed in technical disciplines such as architecture, engineering, and industrial design, these programs were gradually adopted by artists as tools for creative production. One of the most significant shifts during this period was the **replacement of direct physical interaction with materials** by **screen-mediated manipulation of data**, transforming how form was conceived and constructed.

The advancement of **3D modeling techniques** during this era marked a turning point where digital sculpture was no longer perceived merely as a design tool but began to emerge as an **autonomous field of aesthetic expression**. The ability to create and manipulate virtual forms opened up new artistic possibilities, enabling complex compositions that transcended traditional material limitations.

Simultaneously, the rise of **virtual reality (VR)** technologies prompted artists to **reconceptualize space and form**. For example, **Jeffrey Shaw's** interactive VR installations invited viewers to engage directly with digital sculptures, offering immersive and participatory experiences that redefined the spatial relationship between artwork and audience. Another significant figure, **Eduardo Kac**, contributed to the concept of **transmedia sculpture** by integrating **genetic information with digital technologies**, thus pushing the boundaries of what could be considered sculptural material.

During this period, digital sculpture evolved into a **multilayered artistic practice**, no longer confined to physical objects. It began incorporating **intangible elements** such as **data sets, genetic sequences, sound waves, and perceptual systems**, expanding the ontology of sculpture and challenging conventional definitions of form and materiality.

4.3 2000–2010: The Rise of Digital Aesthetics and the 3D Printing Revolution

The 2000s marked a period of significant acceleration in the development of **digital sculpture**, both in theoretical and technical terms. The introduction of **3D printers** into artistic practice enabled digitally designed forms to re-enter the physical world. This advancement led to a **redefinition of the boundary between the digital and the physical**. Artists were now able to produce their sculptural designs **directly through machines**, without the need for manual intervention.

During this period, artists working with **parametric design**, **fractal geometries**, and **algorithmic generation** came to the forefront in aesthetic discussions. Digital sculpture began to be seen not only as a visual art form but also as a **mathematical structure**. Artists constructed multilayered narratives in their works by incorporating **data derived from nature**, **social media interactions**, **architectural forms**, and **historical documents**. These approaches emphasized the potential of digital tools to encode and transform complex systems into sculptural expression.

The convergence of **computational design principles** with **automated fabrication technologies** during this decade fundamentally reshaped both the materiality and conceptual grounding of sculpture. Digital aesthetics was no longer limited to virtual environments; it was now being physically manifested through precision-driven, machine-mediated processes, establishing a new paradigm for contemporary sculptural practice

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4.4 Post-2010: Data, Artificial Intelligence, and the Post-Digital Era

Since the 2010s, advanced digital technologies such as **big data**, **artificial intelligence (AI)**, and **machine learning** have become defining elements in artistic production. During this period, digital sculpture has increasingly taken on **abstract, multisensory, and computational** forms. The AI-driven digital sculpture projects of **Refik Anadol** stand out as striking examples of this emerging aesthetic paradigm. Notably, works such as *Quantum Memories* and *Machine Hallucinations* go beyond data visualization to offer viewers deeply **sensory and poetic experiences**.

In these projects, digital sculpture is no longer defined solely as a tangible object; rather, it is reimagined as a **state of consciousness**, a **layer of memory**, or an **algorithmic dream**—functioning as dynamic "**data**

organisms." This shift redefines sculpture in terms that are computational, ephemeral, and experientially immersive.

Simultaneously, the rise of **NFTs (non-fungible tokens)** and **blockchain technology** has transformed digital sculpture into **ownable, transferable, and economically valuable digital assets**. These developments have necessitated a fundamental reevaluation of key artistic concepts such as **materiality**, **authenticity**, and **value**. The post-digital era, thus, challenges traditional assumptions about what constitutes an artwork, who its creator is, and how it is experienced and exchanged.

5. Transformation of Production Processes

Historically, sculpture has been grounded in a production practice that relies on **direct physical engagement with materials**, requiring intensive manual labor and technical mastery. Processes such as stone carving, clay modeling, and metal casting have traditionally been integral to the artist's bodily skill and material knowledge. In this sense, traditional sculpture can be defined as a form of expression rooted in the shaping of **tangible substances**.

However, the integration of **digital technologies** into artistic production processes has led to a **profound paradigm shift** in sculptural practice. Sculpture is no longer confined to a purely physical construct; it now also exists in **digital and virtual environments**. In this new approach, physical materials are replaced by **data, algorithms, software, and digital modeling systems**.

This transformation is not merely technical—it also marks a rupture in **aesthetic, conceptual, and experiential dimensions**. The artist is no longer just a maker of physical objects, but a **producer** who interprets data, manages algorithmic processes, and employs digital tools creatively. Accordingly, the contemporary artist's studio is no longer equipped primarily with traditional tools but instead with **software platforms, artificial intelligence systems, and data servers**—a space of computational creation.

One of the most striking examples of this transformation can be seen in the work of **Refik Anadol**. His productions reveal how **data-driven aesthetic forms** can be transformed into **abstract and poetic expressions**. In his project *Quantum Memories*, Anadol processed quantum noise data collected from the National Computational Infrastructure of Australia using machine learning algorithms, transforming it into a high-resolution **audio-visual installation**. Here, data is not treated merely as statistical information

but also as **aesthetic material**, and AI is positioned as a **creative agent** within the production process (Anadol, 2020).

Similarly, in the *Melting Memories* series, Anadol utilized EEG (electroencephalography) technology to collect brainwave data related to memory experiences. These datasets were then processed through algorithmic systems to create **visual structures**. The resulting digital sculptures were **fluid, dynamic, and ever-evolving**, as opposed to the static and solid forms of traditional sculpture. In these works, **permanence and materiality** are replaced by **ephemerality, motion, and data-driven form** (Anadol, 2018).

Digital production processes radically redefine the artist's relationship with material. "Material" is no longer fixed and physical but instead becomes **fluid, variable, and abstract**. As artists train algorithms or structure datasets, they simultaneously engage in a process of **meaning-making**. In this context, production is not solely a technical operation—it becomes a **conceptual analysis** and **aesthetic interpretation**. Furthermore, the **reproducibility**, **multi-layered media presentation**, and **spatial manipulation** enabled by digital environments transform how sculpture is experienced—turning it into a living organism that interacts with time and space (Çelenk & Kurak Açıcı, 2022).

In conclusion, **digital sculpture production** represents a **paradigm shift** that profoundly affects the artist's role, tools, and intended aesthetic impact. In this new production model, **algorithmic interaction replaces physical contact**, making the **process-oriented** and **interactive** nature of contemporary art even more visible. Refik Anadol's work exemplifies both the **technological and poetic potentials** of this transformation, reinforcing the significance of digital sculpture within the landscape of contemporary art.

6. Innovations in Audience Experience

Throughout art history, the viewer has traditionally occupied a **passive position**—the artwork was regarded as a static object, and the viewer as an external observer. Although this relationship began to be questioned in the modern and postmodern periods, it is the integration of **digital technologies**, particularly in the field of digital art, that has **radically redefined** the interaction between the artwork and its audience. Technologies such as **augmented reality (AR)** and **virtual reality (VR)** transform the viewer into an **active subject**—no longer merely observing, but participating, navigating, transforming, and even becoming part of the artwork itself. This shift moves

the artistic experience beyond visual perception, turning it into a **multisensory, spatial, and cognitive process**.

AR technologies integrate digital content with the physical world, adding a virtual layer to the viewer's real-life environment. In this way, the artwork is no longer confined to the walls of galleries or museums; it can enter the viewer's everyday spaces. **VR technologies**, on the other hand, immerse the viewer in a fully virtual environment, offering an **experience detached from the physical world**. Through such technologies, even sculpture—a medium traditionally defined by materiality and spatiality—can be reconstructed within the digital plane, gaining **new dimensions of experience**. In this context, **digital sculpture** functions not only as an "object," but also as an **"environment for experience."**

A striking example of this transformation can be seen in **Refik Anadol's** *Machine Hallucination: Sphere*, exhibited in 2023 at **The Sphere (Las Vegas)**. Presented within a massive sphere surrounded by 360-degree LED panels, the work places the audience inside a **monumental data visualization** processed by artificial intelligence. Anadol draws from visuals of cities, architecture, natural landscapes, and scientific observations—processing them with AI to create a **sensory world** that is not merely observed but **interacts directly with the viewer's spatial perception**. Coordinated elements of **sound, light, and motion** create an immersive experience where the viewer navigates through a universe of data. This experience exists in a **liminal space**, somewhere between physical reality and digital simulation.

Visual 5. Anadol R.- Las Vegas- Machine Hallucination: Sphere

Such works not only expand the **boundaries of digital sculpture**, but also offer viewers the opportunity to **rethink their relationship with art**. The viewer is no longer a passive interpreter in search of meaning but becomes an **actor who directly influences the form and evolving structure of the artwork**. Through interactive systems, some digital sculptures are now programmed to respond to **audience behaviors, voices, movements, or even biometric data**. As a result, the art experience becomes not only individual and subjective but also a **reciprocal process of communication**.

Moreover, this mode of experience contributes to the **democratization and accessibility of art**. The circulation of digital content via virtual platforms removes **spatial and geographic limitations**, enabling broader audiences to engage with artworks. Especially in the post-pandemic era, **digital exhibitions, VR museums**, and **interactive art applications** have proven that overcoming physical space constraints is not only possible but already within reach.

In conclusion, the new possibilities provided by digital technologies have transformed not only the **production** of art but also its **perception and experience**. With AR and VR, the viewer is no longer an external observer circling the artwork, but becomes an **integral component within the artwork—shaping and evolving with it**. Refik Anadol's work exemplifies this transformation by merging aesthetic and technological dimensions, playing a **pioneering role** in defining the new experiential modalities of contemporary art.

7. Societal and Cultural Reflections

Digital sculpture is not only an aesthetic form of expression but also a **powerful medium** capable of interpreting the **cultural, political, and sociological issues** of contemporary societies. The integration of new media technologies into art allows artists to move beyond traditional forms and produce **multi-layered**, often **critical works** that resonate with the spirit of the times. In this context, digital sculpture functions as a **platform** where both individual and collective memories are visualized and where issues such as **identity, migration, environment, data security, AI ethics**, and **digitalization** are critically addressed (Kırca, 2024).

While traditional sculpture has often been evaluated in terms of **permanence, historical representation**, and its **connection to physical space**, digital sculpture replaces permanence with **fluidity** and transforms solidity into **flexible and variable data structures**. This not only provides

formal freedom for the artist but also enables the **amplification of cultural expressions**, the **visibility of multiple identities**, and the **translation of global concerns from local perspectives**. The relationship digital art establishes with time—by archiving the past, interpreting the present, and imagining the future—positions digital sculpture as a **"cultural memory device"** (Kırca, 2024).

Within this framework, the works of **Refik Anadol** offer a multi-layered narrative that includes **cultural representation** and **social critique**. His piece *Unsupervised* (2022), for instance, processes MoMA's collection data using an AI system to transform art history into an **abstract and dynamic form**. The project reveals the data-reducible structure of art history and its reinterpretation by machines, offering a **critical perspective on algorithmic epistemology** and institutional collection policies. Anadol's work in this sense is not merely data visualization, but also a **reexamination of cultural production processes**.

Similarly, in works like *Winds of Boston* or *Seoul Haemong*, Anadol uses **urban data** to aesthetically express **spatial memory**. These works bring not only the physical aspects of cities but also their **cognitive, cultural, and emotional dimensions** into the domain of art. Here, digital sculpture becomes a tool that **analyzes individual and collective emotional states**, **reconstructs urban memory**, and **assigns new meanings to space**. The digital traces of individuals in global cities are no longer just commercial or technological—they become **legible in artistic terms** as well (Anadol, 2017; Anadol, 2019).

The social impact of digital art extends beyond the aesthetic level to the **relationship it builds with the viewer**. Interactive digital sculptures can be programmed to **respond to audience behavior, voice, movement, or biometric data**, creating scenarios that prompt viewers to reflect on **their social positions and personal identities**. Such installations can lead to **critical awareness of societal norms**, transforming digital sculpture into a **space of participatory critique**. In this context, the artist is not only a creator but also a **social commentator**, and art becomes **a catalyst for dialogue** rather than a passive object.

One of the most compelling aspects of digital sculpture in terms of cultural representation is its ability to provide **visibility to marginalized narratives**. Voices that have historically been excluded from mainstream art platforms can now find expression through the **accessibility of digital media**. Topics such as **environmental degradation, migration experiences, digital surveillance, and gender roles** are addressed through digital sculpture and new media art in **broader, more polyphonic contexts**. With the global

circulation capabilities of **virtual exhibitions, social media**, and **NFT platforms**, digital sculpture is not only a work of art but also a **node in a cultural network** (Gezer, 2024).

In conclusion, digital sculpture has become a **platform that reflects and reinterprets** the technological, cultural, and social dynamics of the present era. Artists like **Refik Anadol** use this medium not only as a new form of artistic expression but also as a **tool for cultural critique and social awareness**. In this respect, digital sculpture represents a field in which contemporary art is transformed not only **formally**, but also **conceptually**. Its multi-layered narrative structure and critical potential—shaped by phenomena such as **globalization, digitalization**, and the **data society**—make digital sculpture a highly valuable area of research in **art theory and cultural studies** today (Gezer, 2024).

8. Future Perspectives

The future of digital sculpture promises not only formal transformation but also **conceptual and ethical shifts**, evolving in tandem with the rapid development of technology. Innovations in **artificial intelligence (AI)**, **machine learning (ML)**, **generative adversarial networks (GANs)**, **biotechnology**, and **quantum computing** are not merely supportive of artistic production; they are **redefining the nature of the artist**, the **creative process**, and the **relationship between the artwork and the viewer**. AI-assisted artistic production, in particular, is generating **autonomous and unpredictable creative outcomes** in digital sculpture, repositioning the role of the artist and framing the machine not as a passive tool, but as an **active co-creator** within the artistic process.

The direct participation of AI algorithms in aesthetic decision-making has sparked philosophical and cultural debates that question the **human-centered nature of art**. While traditional conceptions of creativity are linked to human emotion, intuition, and consciousness, AI-driven digital sculptures reframe creativity through **data sets, algorithmic processes,** and **learning models**, raising profound aesthetic and ethical questions: *Who is the creator? Can an algorithm replace the artist? Who owns a work generated by an autonomous machine?*

In light of these questions, **Refik Anadol's** work offers compelling insight into future directions of digital artistic practice. His piece *Quantum Memories* (2020), for instance, processes datasets derived from Google's quantum research laboratories using AI to **visualize abstract forms beyond**

human imagination. In this work, Anadol emphasizes the machine's capacity to operate in a manner akin to the **subconscious**, using technology not merely as a tool but as an **entity capable of dreaming**. This project opens the door to a **shared consciousness between human and machine**, suggesting that the future of art may not be grounded solely in human emotions but also in **alternative realities experienced by machines**.

Another key trajectory for the future is the increasing autonomy of **generative AI**, which is becoming more directly involved in the **formal language of art**. GAN-based systems, trained on millions of visual data points, are now capable of producing **novel aesthetic forms** and even constructing their own distinctive "styles." In this context, art-making is no longer solely about creation—it is also about **training**. The artist is redefined not just as a creator of works, but as a **data curator, algorithm trainer,** and **aesthetic systems engineer**.

Consequently, the future of digital sculpture necessitates a **multidisciplinary approach**. Alongside the artist, **engineers, data scientists, software developers, and even neuroscientists** are becoming active participants in the creative ecosystem. Within this ecosystem, the artwork must be understood not only as a visual representation, but also as a **technical process, ethical proposition, and societal statement**. For example, interactive sculptures shaped by neuro-data from the human brain bring together art, neuroscience, and ethics in profound and novel ways.

Future digital sculptures will be increasingly **responsive, adaptive, and intelligent**. Works that react to **biological data**—such as heart rate, perspiration, or brainwaves—will be capable of reading the viewer's emotional or physical state and offering **personalized experiences** in real time. These sculptures will perceive the viewer not just as an observer, but as an **interconnected organism**, forming a **symbiotic relationship** with the artwork. As a result, the artwork becomes not a static object, but a **living, dynamic, self-sustaining "cyber-organism."**

However, the growing prevalence of AI-generated content also introduces **complex questions** regarding **authenticity, copyright**, and **ethics**. Who owns the rights to an image produced by AI? Are the visual datasets used for training ethically sourced and properly attributed? In cases where the artist acts merely as a manager of algorithms, how much of the **subjective creative value** is preserved? These are not only artistic questions but also **legal and cultural challenges** that will increasingly demand attention in the coming years.

In conclusion, the future of digital sculpture is evolving into a **multi-dimensional, collaborative, and technologically intertwined art form**. As aesthetic decisions are increasingly shared with machines, and sculptures respond to the viewer's biological inputs while transcending physical space into virtual realms, the question is no longer just *what art is*, but *what it can become*. These emerging creative paradigms are poised to transform not only artistic practice but also our **relationship with technology**, our **modes of creative expression**, and even our **core social values**. The future of digital sculpture will continue to take shape at the intersection of **technology and aesthetics**, aiming to reveal the **co-creative potential between humans and machines**.

9. Theoretical Background and Conceptual Framework

To fully comprehend the scope of digital sculpture as an artistic practice, it is essential to examine the **theoretical foundations** upon which it is built. Scholars and theorists who have explored the impact of technology on artistic production have explained the transformation of art's nature in the digital age through various conceptual lenses. Accordingly, the **conceptual framework of digital sculpture** is shaped by **media theory, new media art**, **posthuman aesthetics**, and **data-driven art theories**, among others.

Marshall McLuhan's famous assertion, *"the medium is the message,"* provides a foundational entry point for understanding digital sculpture. According to McLuhan, the **technological medium itself shapes the nature of the message**; thus, artworks produced through digital tools gain meaning not only through content but also through the **affordances and limitations** of the medium. In the context of digital sculpture, the medium consists of **software, algorithms, and data flows**, and the message is consequently formed through their interaction.

The theoretical contributions of **Lev Manovich** further solidify the conceptual basis of digital sculpture. In *The Language of New Media* (2001), Manovich identifies five principles of digital aesthetics: **numerical representation, modularity, automation, variability,** and **transcoding**. These characteristics help explain digital sculpture's **non-physical, reproducible, reconfigurable**, and **experientially dynamic** nature. In particular, the principle of **variability** highlights how each viewer may experience a digital artwork differently, emphasizing the **pluralistic** nature of digital art.

Christiane Paul, a prominent new media theorist, draws attention to the societal and cultural dimensions of digital art. According to Paul, digital art is not just an aesthetic practice, but a **cultural mode of production** that operates within **information systems, networks,** and **interactive platforms**. From this perspective, digital sculpture becomes more than a visual object—it serves as a **conceptual platform** through which social data are translated into aesthetic forms. Here, data functions not only as **content** but also as the **structural carrier** of the aesthetic experience.

Meanwhile, **posthumanist thought** explores how digital art challenges human-centered paradigms. In *How We Became Posthuman* (1999), **N. Katherine Hayles** analyzes human–machine relations and develops a new notion of subjectivity grounded in the **digitalization of consciousness and embodiment**. This perspective resonates with artists like **Refik Anadol**, who position AI systems as **creative partners**. The collaborative interaction between artist and algorithm highlights a shift away from the classical model of the artist as an individual genius and toward a **networked, collective production model**. Within this framework, digital sculpture emerges as a **hybrid art form** shaped not only by human agency but also by non-human entities.

Another key conceptual approach is **data aesthetics**. This framework treats data not only as information but also as **aesthetic material**. Theorists such as **Lev Manovich, Mark Hansen,** and **Johanna Drucker** emphasize that the visualization of data is not purely a technical act but also a **cultural and philosophical one**. Refik Anadol's works such as *Melting Memories* and *Quantum Memories* reinterpret abstract notions—such as **memory, consciousness**, and **quantum physics**—through data, offering the viewer an **almost intuitive, affective experience**. Here, digital sculpture translates data into **abstract imagery**, generating not only knowledge but also **emotional and sensory engagement**.

Finally, **Félix Guattari's** concept of the **"three ecologies"**—mental, social, and environmental—offers a valuable framework for understanding the broader impact of digital sculpture. Digital sculpture has the potential to **transform not only the individual aesthetic experience**, but also **social relationships**, **digital culture**, and **ecological awareness**. Data-centric art practices often address urgent issues such as **climate change, surveillance capitalism,** and **digital memory**, contributing to the emergence of a **new form of political aesthetics**.

Evaluation

The historical evolution of digital sculpture reveals not only the transformation of technological tools but also a profound shift in the **artist's intellectual, conceptual, and aesthetic approach**. Throughout the history of art, the tradition of sculpture has been defined for centuries by a strict discipline of materiality: artists worked with **stone, bronze, clay, or marble**—physical substances characterized by permanence, weight, and manual manipulability—centering the **material existence of the object**. This understanding rendered sculpture a **timeless, static, and often authoritative** form. With the advent of digital sculpture, however, this static model began to dissolve, prompting a **redefinition of the nature, purpose, and function of sculpture**.

In the digital age, the artist is no longer just a craftsman or a form-giver, but also a **coder, system designer, data curator,** and **algorithmic thinker**. The physical form of sculpture has been supplanted by **data, processing systems**, and **virtual spaces**, and the relationship with the viewer has likewise transformed. Artworks are no longer merely objects to be displayed, but **environments to be navigated, interacted with**, and sometimes **reshaped through audience participation**. Technologies such as **augmented reality (AR)** and **virtual reality (VR)** have liberated sculpture from physical constraints, enabling it to exist in **multilayered spatial dimensions**.

In this context, digital sculpture has evolved beyond being a form of aesthetic expression to become a **critical tool**. Artists are now able to use datasets to **draw attention to social issues**, employ AI algorithms to **question notions of subjectivity**, and address global crises—such as **climate change, migration, and identity politics**—through digital material. Digital sculpture thus extends the intellectual horizon of contemporary art, establishing itself on an **interdisciplinary foundation**.

Moreover, this transformation has had a **radical impact on the notions of ownership, authenticity, and distribution** in art. With the emergence of **blockchain technologies** and **non-fungible tokens (NFTs)**, digital sculptures can acquire **commercial value** without existing materially and can be shared on a **global scale**. These developments invite renewed discussions around the structural frameworks that define art—from market relations to audience engagement.

From an art historical perspective, the rise of digital sculpture represents a **rupture between classical artistic paradigms and post-digital**

thinking. Art is no longer merely **form**, but also **process**; not solely **object**, but **experience**; not simply an act of **individual creation**, but one of **collective, network-based, data-driven production**. This transformation detaches aesthetics from technique, shifts the audience away from passive reception, and recasts the artist not as a solitary creator but as a participant in a **new creative ecosystem**.

In conclusion, digital sculpture cannot be evaluated solely in terms of its **formal or technical characteristics**. As an art form, it enables a **multilayered perspective** on the contemporary world by engaging with **intellectual, emotional, and sociocultural dimensions**. The future will be shaped not only by more advanced technologies, but also by **theoretical developments** that redefine the meaning, function, and limits of art. In this regard, digital sculpture is poised to be one of the most **significant creative and critical components** of that future.

Conclusion

Digital sculpture emerges not merely as a technological innovation but as a **transformative paradigm** that profoundly reshapes the meaning and function of contemporary art. Rapid advancements in digital technologies—especially artificial intelligence (AI), machine learning (ML), augmented reality (AR), virtual reality (VR), generative algorithms, and big data analytics—not only introduce new tools for artistic expression but also **reconfigure the processes of creation, presentation, and perception** in multidimensional ways. In this context, digital sculpture constitutes an **aesthetic domain** that challenges the boundaries of traditional art, destabilizes the fixity of form and singularity of meaning, and repositions the viewer from passive observer to **interactive participant**.

One of the most striking aspects of this transformation is the **redefinition of the artist's role**. Whereas the traditional sculptor worked with tangible materials through manual labor, the digital sculptor has become a **curator of data**, a **system designer**, and a **multidisciplinary producer** who operates through coding and computational systems. Creative activity is no longer confined to the production of aesthetic form; it intersects with **technical knowledge, cultural critique, philosophical inquiry**, and even **scientific intuition**. In this sense, digital sculpture transforms the identity of the artist into a **fragmented and plural entity**.

Moreover, the practice of digital sculpture has **redefined spatial constraints** in art. While traditional sculptures are permanent, site-bound, and

often associated with public space, digital sculptures exist within **virtual environments**, allowing for **flexibility, permeability, and reproducibility**. Particularly through VR, these works inhabit **temporal and spatially detached aesthetic realms**, fundamentally altering the viewer's relationship to the artwork. The artwork is no longer static; it is **dynamic**, responsive to interaction, and **shaped by personal experience**. The viewer becomes not just a receiver but an **active agent** within the artwork itself.

Artists like **Refik Anadol** have harnessed this new creative potential not merely as a formal innovation but as a **method of engaging with contemporary social and cultural concerns**. In Anadol's works, AI functions not just as a tool but as a **digital simulation of the unconscious**, an archive and re-expression of **collective memory**, and a mechanism for rewriting cultural narratives through data. These approaches demonstrate that digital sculpture is not just an aesthetic category, but also a **mode of thinking**, a **model of cultural production**, and an **ontological inquiry**. Here, art transcends individual expression to become a structure of thought with **social, political, and ethical dimensions**.

The rise of digital sculpture also provokes critical questions: How does AI's role in decision-making alter the definitions of **authenticity** and **creativity**? Who owns artworks generated by algorithms? How should the **aesthetic value of data-driven art** be assessed? These questions raise important debates not only in art theory but also in **law, ethics, sociology**, and **philosophy**. Therefore, the future of digital sculpture must be seen not solely as a consequence of technological progress but as a **multidisciplinary, theory-informed domain** that invites collaboration across fields.

In conclusion, digital sculpture calls for a **radical re-evaluation of the nature of art**, transcending classical paradigms through its engagement with **evolving audiences, mutable forms, and emergent creative processes**. In an era where technology advances rapidly and AI becomes a generative force, art sheds its fixed and static character, transforming into something **fluid, interactive, and perpetually reconfigurable**. In this regard, digital sculpture represents not only a branch of contemporary art but also a **symbol of future art**, a **cultural reflection of human–machine relations**, and a **forerunner of new aesthetic forms**. This transformation signals that we stand at the threshold of a **new creative culture**—one that will reshape not only the field of art but also the human condition itself.

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Contributions of Digitalised Business Functions to Women Entrepreneurs

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ABSTRACT

Technology has been transforming almost every decade in recent years and offers new and valuable products to our lives. Digitalization, which develops due to technology, can directly or indirectly affect almost every field. Entrepreneurship, which is extremely important for countries, can get its share of these developments. Most of the entrepreneurs in societies are men. It is observed that women also engage in initiatives with different ideas and are successful. Digitalization in the functions of businesses can enable women who are disadvantaged due to some social reasons to turn this situation

Keywords – women, entrepreneur, female entrepreneur, digitization, digital business

INTRODUCTION

Starting a business, providing employment, creating social and economic wealth is seen as a key factor in the economies of countries and is supported (Wong, Ho & Autio, 2005). For this reason, individuals prefer to be entrepreneurs by pursuing their own dreams instead of working for the dreams of others (Bilgiseven & Kasımoğlu, 2020). Entrepreneurship, which is characterised as an idea into action (Cengiz, 2018), is the result of a series of factors (Raijman, 2001). Entrepreneurship as a career choice brings with it the necessity of being creative and having superior problem solving skills (Abdulwahab & Al- Damen, 2015). The biggest reason for an entrepreneurial event is the change in one's life. The intention to take risks and past experiences, such as losing one's job, midlife crisis or after one's financial situation has become more secure (Elfving, Brännback & Carsrud, 2009; Shapero & Sokol, 1982). In addition, securing individual employment (Souitaris, Zerbinati & Al-Laham, 2007), the desire for profit and gain, the idea of social reputation, the desire to pursue dreams, the precariousness of the current job or job dissatisfaction, the mission to realise an idea or purpose, high self-confidence, providing employment for family members, the desire to do independent business, the lack of another option can be the prerequisite for entrepreneurship (Kılınç & Kanayıran, 2020).

Information technologies have shown a rapid development in recent years. The increase in the functionality of computers and smart devices day by day

and the fact that access to the internet is possible at almost every point have provided many advantages for businesses. One of these advantages is e-commerce applications (Hieber, 2002). Although its history is not very long, e-commerce has become indispensable for many businesses, and this effective communication between businesses and customers has enabled further development of products and services (Seddon, 2000). Porter (2001) claimed that in the near future all commercial transactions may become electronic and even using the concept of e-commerce may be unnecessary (Kutlu Karabıyık, 2021). E-commerce applications have increased the marketing opportunities and capabilities of businesses. In addition to contributing to the marketing function of businesses, information technologies have had a direct impact on business functions such as management through decision support systems, finance through banking applications, and human resources through employee websites. The fact that information technologies are so fast has led to the implementation of e-government applications, which are expressed as the use of information and communication tools in the provision of state services by directing states to such applications (Naralan, 2009). Tax Office Automation Project (Hepaksaz & Hayrullaho, 2011), which is an application add-on within e-government, can be effective on the accounting function of enterprises

Due to the roles assigned to them in social life, women may have some duties that they have to fulfil. In addition to these tasks, the life of women who take on an entrepreneurial role may become more difficult and the need to use time more efficiently may increase, and they may be disadvantaged compared to male entrepreneurs. For this reason, this study aims to investigate what kind of contributions of information communication technologies, in other words, digitalisation, to the increasing number of women entrepreneurs in business life within the framework of business functions. For this purpose, many digital innovations from websites to mobile applications will be within the scope of the research. It is expected that this study will contribute to the literature since such applications will be analysed in terms of business functions.

RESEARCH SUBJECT CONCEPTS

1. Management

Management is defined as a process that includes planning, organising, directing, executing and controlling all the resources of an organisation in line with a purpose (Ülgen & Mirze, 2020). As it is understood from this definition, the primary function of management is planning. The success of planning is based on fast and accurate information. The increase in digital opportunities makes it possible to access information faster and easier (Tekin & Küspeci, 2021). The effective use of this information in line with the objectives of the enterprises can be possible with some digital technologies such as executive information systems (Avolio, Kahai & Dodge, 2000). These systems, which help managers to analyse problems and solve complex problems (Laudon & Laudon, 2018), provide four types of information to the manager in the organisation: descriptive, diagnostic, predictive and directive. Especially since predictive systems include forecasts (James, 2017), they can make it easier to make plans and increase the probability of realisation of plans. There are some digital applications that facilitate the work of managers related to planning. One of them is Enterprise Resource Planning, which is defined as "a software system that includes the functions of planning, coordinating and controlling the supply, production and distribution resources in different geographical regions in the most effective and efficient way in order to meet customer demands in the most appropriate way in line with the strategic goals and objectives of an enterprise" (Postacı, Belgin & Elkan, 2013). As can be understood from the definition, Enterprise Resource Planning can play an important role in fulfilling the vital tasks of management such as planning, coordination and control. All efforts of management to achieve goals and objectives are associated with a decision-making process. Decision-making is important in organisational life as in all areas of life (Ceschi, Demerouti, Sartori & Weller, 2017). Because decision making is shown among the most important activities of management (Vohs et al., 2008) and even the essence of organisational activities (Harrison & Pelletier, 2000). Decision making is briefly defined as (Eren, 2016) choosing the most appropriate one among the available alternatives in order to achieve the objectives. Decision making is an organisational process and includesmanagerial behaviours that make it

possible to achieve organisational goals. Every decision taken by the management should support other decisions made previously. Thus, the quality of decision making, in other words, the accuracy rate increases. Correct decisions also make it easier to be successful in an intensely competitive labour market. Decision making is both a difficult and risky management activity (Altan, 2020). For this reason, managers can utilise the opportunities of technology in order to make accurate decisions. These systems, referred to as decision support systems, are computer-based systems that enable decision-makers to make decisions with the help of their own reasoning abilities (Hersh, 1999). The increase in the problems faced by managers in decision making, the increasing difficulty of competition and the developments in information systems due to technological developments have led to the emergence of decision support systems .The aim of decision support systems is to increase the effectiveness, not the efficiency of the manager (Alagöz, Öge & Koçyiğit, 2013). Therefore, managers endeavour to close their information gaps and improve the quality of their decisions by using these systems (Long, 1989). In small businesses without a professional manager, the duties and responsibilities of planning and decision-making mostly belong to the business owner or, in other words, the entrepreneur. For this reason, taking advantage of the opportunities brought by digitalisation can directly affect the success of the entrepreneur.

2. Production

As a result of technological developments based on information and knowledge, many digital methods used in production have been developed. In general, technology or in other words digital-based methods used in production management can be listed as ERP (Enterprise Resource Planning), MRP (Material Requirements Planning) and MMP (Master Manufacturing Planning (Aksel, Arslan, Kızıl, Okur & Şeker, 2013). ERP is a comprehensive software with a modular structure that enables businesses to manage all processes from procurement to distribution with the support of an integrated information/data management system (Kumar, Maheshwari & Kumar, 2003). ERP can be defined as integrated management systems that enable the efficient use of factors suchas machinery, materials and labour required for the production of goods or services in enterprises (Cankurt & Temurtaş, 2010).

With digitalisation, it is obvious that there are many changes and transformations in the production systems and management of enterprises producing goods. This change and transformation is also experienced in service producing enterprises. Examples of digital transformations in the health sector include telehealth and e-health applications (Ertek, 2011). Digital services in the education sector can be offered through online education and e- learning tools. With many digital applications that enable online education, training can be easily offered to participants at the desired time regardless of the location (Hajhashemi, Anderson, Jackson & Caltabiano, 2008). Digitalisation in the tourism and accommodation sector is in the form of online booking and virtual reality. Reservations can be made online through many platforms that offer services in this field through the Internet, and thanks to virtual reality technology, places to stay can be visited as virtual tours (Saçlı & Yurtlu, 2020; Timur & Köz, 2022). Software such as ERP software used in the production of goods and other digital tools used in service production and delivery have become important and indispensable applications that enable managers or entrepreneurs to make decisions that facilitate their work and thus be successful.

3. Marketing

Marketing (Jeffcoate, Chappell & Feindt, 2002), which is a concept that includes all activities that will facilitate the delivery of goods and services from the producer to the consumer, is the planning and management of the pricing, promotion and distribution of ideas, products and services to achieve individual and organisational goals (Bovée, Thill & Mescon, 2005). Due to today's technological possibilities, access to products, services and information is very fast compared to the past. In addition, this information can be processed in various digital environments and turned into meaningful data, which can provide competitive advantage to businesses (Deloitte, 2016). Increasing digitalisation and the opportunities in digital technologies have enabled marketing to enter the digital field (Jaas, 2022). Digital marketing is a marketing method that aims to direct the consumer to purchase through interaction and communication between the consumer and the business, using methods different from traditional methods in order to promote products and services directly or indirectly (Kotler et al., 2021). Websites, search engines, social networks, mobile applications and blogs are generally used for digital marketing (Shaik, Moyeenudin, Arun, Anandan &

Janahan, 2018). Websites are one of the most important digital channels that businesses use to promote their products and services. These sites offer direct sales opportunities as well as the promotion of products and services. The possibility of direct sales prevents businesses that produce goods from being confined to a store and allows them to market their products to many points within the country and even abroad. Another digital marketing tool is social networks. Social networks are the most preferred virtual environments today and especially young people spend a lot of time. Although it is claimed to have some negative effects such as addiction and wasteful spending of time, it offers great promotional opportunities for businesses. Since many people spend a long time in these networks and visit these networks almost every day, the advertisements to be made by businesses can be effective in marketing their products and services. Some businesses can open accounts directly on these networks and publish videos promoting their own products and even reach many consumers through the promotions of people called phenomena. Businesses of almost all scales endeavour to use these networks, which are considered valuable in terms of marketing, and they can have the opportunity to promote their products and services to potential consumers through these channels. Virtual networks have become an important digital marketing tool, especially for new entrepreneurs, women's co-operatives and businesses that do not have enough budget for advertising.

4. Human Resources

The long-term effectiveness of an organisation depends on market conditions, competitive strategies, human resource practices and managerial support (Sheppeck & Militello, 2000). In other words, along with the other three elements, human resource practices are one of the main functions that carry the organisation into the future. The main subject of human resources management is people and it is an organisational function based on evaluating the human resources needed by the organisation and meeting this need in the best and most efficient way (Özgen et al., 2005). In the most general terms, human resource management can be defined as the use of people for the realisation of corporate goals (Mondy, 2017).

Recruitment is one of the most important functions of human resources management. In the absence of digital capabilities, recruitment was a more difficult and labourious process than it is today. Today, with the

help of internet technology and other tools recruitment application tracking systems, storage of candidate data (Sills, 2014) have made the recruitment function easier and more accurate by providing opportunities such as selection among the available ones.

Today, there are different digital media alternatives for job seekers. Some of them are career sites/job advertisement sites, corporate websites, electronic recruitment applications and service providers and mobile application, i.e. filling in the job application form with a QR code or a link (Aksoy Uğurlu & Doğan, 2023). Another recruitment practice is recruitment through social media tools, also called "Social Recruitment", whereby businesses can access qualified candidates in a short period of time (DeCenzoRobbins & Verhulst,2017; Cappelli, 2019). The process of procurement and selection of human resources has two dimensions. The first of these dimensions is employers, while the other is job seekers. While the digitalisation of these processes provides some opportunities for job seekers, it also provides some benefits to employers, i.e. businesses. These benefits can be listed as; fast access to the desired information, collecting CV at the desired standards, publishing advertisements 24/7 independent of time and physical space, enabling to promote their businesses and improve their image, preventing loss of time, reducing recruitment costs, accessing up-to-date information and qualified staff at any time, creating a more efficient recruitment method and expanding the candidate pool due to the possibility of reaching many candidates (Saldamlı, 2008). Today, artificial intelligence applications, which we have started to see more and more in all areas of life, have started to find a place in recruitment. Analyses such as reviewing the information of the applicants, eliminating those who are not deemed sufficient, examining the candidate's facial expressions, tone of voice and mood through virtual interviews and evaluating their competence for the current position can be done with these artificial intelligence tools just like recruitment experts do. The fact that these tools are free from subjectivity and prejudices is seen as an achievement of recruitment processes (Akduman, 2019). All these digital tools facilitate the work and transactions of managers and entrepreneurs and help them to make more accurate decisions in the provision of human resources that are most valuable for their organisations.

5. Accounting and Finance

Accounting, which is called an information system, is the sum of resources such as people, processes and hardware that enable the transformation of financial data into information that will facilitate the work of decision makers (Bodnar & Hopwood, 1998). Increasing digitalisation and the intensive use of technology in every field (Damasiotis, Trivellas, Santouridis, Nikolopoulos & Tsifora, 2015) has enabled the use of technology-based applications instead of paper-based accounting applications (Karcıoğlu & Binici, 2021). In addition, digitalisation of accounting processes has enabled faster business processes, easier access to wider markets, elimination of time constraints in accounting transactions, reduction of error rates, provision of information security, more effective cash management, collection and auditing, which are vital for businesses (Deshmukh, 2006). Some countries carry out tax transactions through artificial intelligence robots, thus reducing the workload faced by the tax office. In addition, these digital tools communicate with taxpayers via mobile phones using sms or e-mail and inform them about market information, legal changes and tax processes. It can also provide a kind of digital counselling service to business owners by receiving and processing taxpayers' questions and providing answers to these questions (Huang, 2018).

Financial management, which is explained in the business literature with the concept of cash management (Uysal, 2016); It is the process of making and implementing plans through the use of resources to achieve business objectives. Financial management consists of not one but more than one plan that eliminates the problems or concerns of enterprises. In other words, financial management is a series of financial plans that will achieve the goal, that is, a process (Goldsmith, 2021). The widespread use of the Internet, digital technologies, mobile applications, big data and its analysis, BigTech/FinTechalternative finance platforms and customer-oriented product approaches have led to changes in financial services and banking. In addition, algorithmic trading, the use of artificial intelligence, and bots and robo-advisors that can provide investment consultancy (Körpe, 2021) have made the work of entrepreneurs requesting loans in the finance sector even easier. Especially with artificial intelligence applications, lenders can reach entrepreneurs faster and the number of services offered is increasing day by

day. As a result of digitalisation, banks are able to offer almost all of the work and transactions they perform in their branches to their customers through digital technologies (Işkın, 2012). Digital banking, which is defined as the digital access of traditional banking services to customers through internet facilities without a physical obligation (Khillar, 2021), offers institutions the opportunity to work 24/7 without being tied to a physical location (Parasız, 2014). The fact that mobile devices are one of the indispensable elements of digital banking (Pousttchi & Schurig, 2004), FinTech and BinTech companies (Mekinjić, 2019), which have emerged due to digital transformation, make it easier for entrepreneurs to make financial plans and decisions and implement these decisions.

RESULTS AND DISCUSSION

Supporting women entrepreneurs has an important place in increasing the number of entrepreneurs and thus realising the macroeconomic goals of countries. However, almost all of the world is male-dominated societies and this situation causes women to remain in the background in entrepreneurship as in every field. This situation has a negative impact on women's education, career, status, income and wealth and may prevent women from becoming successful entrepreneurs. For this reason, the digitalisation of businesses, in other words, the digitalisation of business functions, can contribute to compensate for the disadvantageous situation of women in this sense. For example, the most important task of an entrepreneur or manager is to make decisions. Because decisions directly affect the success of their businesses and can help carry their businesses into the future. Decision making is a process based on knowledge or experience. The ability of entrepreneurs to process information and make predictions about the future is related to the accuracy of the information obtained. Women entrepreneurs who have not gained enough experience in business life will be able to make effective and efficient decisions and achieve success by using the correct information they obtain thanks to digital opportunities, and perhaps they will be able to make more accurate decisions against their male competitors who rely on their experience and do not benefit from digital opportunities.

The sine qua non of businesses is production. The success of the entrepreneur is related to which goods or services he produces. Entrepreneurs using digital tools such as ERP can optimise production quantities and achieve productivity targets. Digital applications such as ERP are undoubtedly technological opportunities that large organisations benefit from, but there are many digital opportunities that facilitate the work of women entrepreneurs, either at the production stage or in service delivery, and women who take advantage of these opportunities are likely to be successful. As important as it is to produce products and services, realising their sales is a vital issue for the success of an entrepreneur. At this point, digital opportunities come to the rescue of women entrepreneurs. Because the entrepreneur's websites, social networks, mobile applications and online sales sites offer very good opportunities for women entrepreneurs to promote their products. The fact that sales can be made through digital tools can free women entrepreneurs from time and space constraints and them to make sales both within and outside their countries. Thanks to mobile applications, women entrepreneurs can promote and sell their products more easily. Sales sites established for service marketing in the service sector can increase the marketing and sales capabilities of all entrepreneurs, whether large or small. These sites can be used to market five-star hotels, but they can also be used to promote hostels and even small accommodations with one or two rooms.

Another contribution of digital technologies to women entrepreneurs can be realised in the field of human resources. The answer to the question of how to reach successful employees can be given through digital technologies. There are many websites around the world that provide human resources in a professional sense. This makes it easier for women entrepreneurs with large or medium-sized investments to make a choice. However, women entrepreneurs with small-scale investments can also access the right human resources through these sites. At the same time, thanks to some mobile applications, they can reach the right employee they need for their companies.

Digital technologies have long been used in accounting and finance. These opportunities in the field of accounting enable entrepreneurs to make more accurate records and accurate analyses. In this way, it is easier for

entrepreneurs to determine their profit/loss situations and make more accurate decisions about the future. In addition, with many digital applications such as e-declaration, women entrepreneurs can have more detailed information about taxation. Thanks to the free consultancy provided by some digital tax applications, the costs that entrepreneurs have to bear are reduced and it is even possible to have more tax information. Digital finance makes serious contributions to entrepreneurs as well as individuals. Digital tools that can perform financial analyses can enable women entrepreneurs, who may lack deep financial knowledge, to make more accurate analyses and make more accurate decisions about the future of their businesses. Financial tools in the banking sector can ensure the efficient use of time, which is valuable for almost everyone, also for women entrepreneurs.

Digitalisation affects all segments as a part of daily life and enables all business and transactions to be faster and more efficient. Digitalisation in business functions is undoubtedly a situation that benefits all entrepreneurs. However, women entrepreneurs may remain in the background in male-dominated societies and this may hinder their success. If women entrepreneurs benefit from the opportunities and possibilities offered by digitalisation, it may make it possible for them to become more advantageous.

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Investigation of the effect of social media on earthquake awareness and preparedness: a structural model proposal

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ABSTRACT

The importance of preparedness for possible major earthquakes has revealed the need to explore readiness and efforts in order to lessen the impact of disasters. This research aims to investigate the important elements affecting the willingness to prepare for potential earthquake mitigation. The research model proposed in the study was designed by combining the Protection Motivation Theory with the Extended Planned Behavior Theory. Partial least squares structural equation modeling was used to fit the research model and test the hypotheses. In this study, a survey which has been conducted to investigate the intentions and behaviors of people to prepare for the mitigation of the possible effects of an expected earthquake was administered to 257 participants. According to the results of the study, social media significantly affected the earthquake's information awareness, perceived severity and perceived vulnerability. In addition, it was determined that as the earthquake attitude level increased, the behaviors towards reducing the effects of earthquakes also increased. Therefore, it is safe to say that the findings of the study can be used by authorities to enable them to carry out earthquake preparedness and mitigation practices.

Keywords: Earthquake, Residential earthquake preparedness, Earthquake mitigation, Protection Motivation Theory (PMT), Extended Planned Behavior Theory, Structural equation modeling, PLS-SEM

1. Introduction

Earthquake is the event of seismic fluctuations that occur as a result of unexpected energy in the earth's crust. In other words, it can be defined as the shaking of the earth by these waves. Seismic activity refers to the frequency, type and magnitude of the earthquake in the area where it occurs. The magnitude of the earthquake is determined by the Moment-magnitude scale. According to this scale, earthquakes with a magnitude of 3 and below are generally not felt, while earthquakes with a magnitude of 7 and above can be destructive. The depth of the point where the earthquake occurs is also effective on the destruction force, so earthquakes that occur close to the earth cause more damage (Ohnaka,2013).

Earthquakes on the planet's surface can manifest in various ways, including shaking and movement. Instances of a powerful earthquakes taking place close to the surface can even lead to the formation of tsunamis. These seismic vibrations might also initiate landslides and activate volcanic processes.

Turkey is a seismically active country. Turkey is located between both the Eurasian plate and the Arabian plate and the African plate. In addition, it is

in an earthquake zone with the North Anatolian Fault Line, the East Anatolian Fault Line and the West Anatolian Fault Line within its borders. While the East Anatolian and North Anatolian Fault Lines occur with lateral thrusts, the West Anatolian Fault Line occurs with normal faults, causing the Aegean to expand. The Bitlis-Zagros Fault Line, located on the Iran-Iraq border and one of the main parts of the African plate, exerts a thrust on the east of Turkey. Therefore, a subduction zone takes place, and the Eastern Anatolia Region rises a few millimeters every year (Afad,2023).

Throughout history, there have been many earthquakes with devastating effects in Turkey. The two biggest earthquakes among these earthquakes are the 1999 Gölcük Earthquake and the 2023 Kahramanmaraş Earthquakes.

1999 Gölcük Earthquake is a Kocaeli/Gölcük-centered earthquake that occurred on the morning of 17 August 1999 at 03:02 local time. This earthquake, whose instrumental magnitude was measured as Mw=7.8 by the Kandilli Observatory, caused great loss of life and property. This earthquake was felt in the entire Marmara Region, from Ankara to Izmir. According to official reports, there were a total of 17,480 fatalities and 23,781 injuries, with 505 individuals sustaining injuries. The earthquake resulted in the damage of 285,211 houses and 42,902 workplaces. According to a research report from the Turkish Parliament in 2010, the earthquake led to 18,373 fatalities and 48,901 injuries (Jmo,2023). The 1999 Gölcük Earthquake impacted approximately 16,000,000 people with varying degrees. Consequently, it still stands as a highly significant event that deeply influenced Turkey's recent history. This earthquake ranks among the largest in Turkey, considering both its magnitude and the extensive geographical area it affected. Given that it struck the Marmara Region, a pivotal industrial area in Turkey, and had far-reaching effects, it caused considerable amount of distress (Akıncıtürk, 2003).

In Turkey, which has been exposed to the earthquake natural disaster many times before, two earthquakes with magnitudes of 7.8 Mw and 7.5 Mw occurred on February 6, 2023 at 04:17 and nine hours later at 13:24. The epicenters of the earthquakes were Pazarcık and Ekinözü districts of Kahramanmaraş. According to official records, more than 50 thousand 783 people in Turkey and 8 thousand 476 people in Syria died due to earthquakes, and more than 122 thousand people were injured in total. After the earthquakes, more than 24 thousand aftershocks with magnitudes of up to 6.7 Mw occurred. 2023 Kahramanmaş earthquakes, which occurred on the East Anatolian Fault and affected 11 cities, were recorded as the most destructive earthquake experienced in the republican period in Turkey.

The earthquake had its own financial effects, as well. In the statement made by the Ministry of Treasury and Finance, it was stated that a total of 1.6 trillion Turkish Lira (TL) material damage was incurred. However, a total of

351.4 billion TL was lost due to the decrease in national income, in addition to the emergency support and expenditures made to the earthquake area, debris removal activities, insurance payments, loss of income payments, all other supports and expenditures. The cost of this great disaster to Turkey is approximately 103.6 billion dollars. This amount is approximately 9 percent of the 2023 national income expectation and is approximately 6 times higher than the financial loss caused by the 1999 Gölcük Earthquake (Hmb,2023).

When certain studies on effects on earthquakes are examined, Vinnell et al. (2020) showed that Shake Out drill participants have better knowledge of correct protective actions, use of those actions during actual earthquake shaking, and additional preparedness actions, as well as weaker biases such as fatalism. Becker (2017) investigated the impact of the experiences on earthquake. The research identified seven distinct ways in which experiences affect the process of being prepared: stimulating thought and discussion; increasing awareness and knowledge; aiding individuals in comprehending the ramifications of a disaster; shaping beliefs; fostering preparedness; affecting emotions and sentiments; and encouraging engagement within the community regarding disaster-related matters. McCaughey (2017) examined the case of the city of Banda Aceh, Indonesia, where a M8.6 earthquake on 11 April 2012 caused a spontaneous mass evacuation but no tsunami. Quann (2017) investigated how the perceived severity of trauma and rumination mediate the connection between traumatic experiences and posttraumatic stress disorder (PTSD). Additionally, the study evaluated how resilience moderates this mediation process. Junn et al. (1996) examined earthquake preparedness and its correlates in 25 childcare centers located in a southern California community adjacent to the San Andreas Fault.

In order to mitigate this destructive effect of earthquakes, earthquake preparedness behaviors need to be developed. In this study, earthquake preparedness behaviors were investigated to reduce the effects of earthquakes in residences in Turkey. For this purpose, a survey was applied to 257 participants living in various cities of Turkey. Details about the survey will be presented in Sections 2.3. Protection motivation theory was used to investigate earthquake preparedness behaviors.

Protection Motivation Theory (PMT) is a theory claiming that stakeholders' motivation or intention to protect themselves against dangerous situations consists of four basic factors: severity of risks, personal vulnerability to risks, self-efficacy for risk mitigation, and risk mitigation behavior. According to this theory, people's self-protection intentions are undermined by the cost of risk reduction behavior and the rewards of alternative risk reduction behaviors. The PMT is the intermediate process that people use in evaluating threats and choosing between coping alternatives. People use a combination of threat assessment and coping factors to protect

themselves from risk (Martin et al., 2007). The PMT is one of the strongest explanatory theories predicting an individual's intention to take protective actions. It mainly derives from both the threat assessment and the coping assessment. Threat assessment is a combination of two factors: perceived vulnerability to the likelihood of threatening events occurring and the severity of the event's consequences. Threat coping assessments have a three-factor infrastructure. These factors are listed as self-efficacy, response effectiveness and response cost. Self-efficacy can be defined as the individual's ability to cope with or perform the proposed behavior while response effectiveness is basically the individual's belief about the perceived usefulness of his action. Last but not the least response cost refers to the perceptions about the benefits of the perceived opportunity (Ifinede,2012). The PMYT considers the need to engage in one of two types of behavior in response to a threat, either adaptive or inappropriate. Adapted behavior is a type of behavior that is effective in protecting a person from a threat. Inappropriate behavior is doing nothing or engaging in behavior that may increase risk. In the threat assessment, individuals evaluate the probability of occurrence of the threat and the severity of the threat (Shillair et al., 2015).

Upon reviewing the existing literature, it has been realised that PMT is frequently used for catastrophic risks such as earthquakes. Williams et al. (2020) studied flood risk and adaption to it, including the possibility of out-migration, in two flood-prone coastal locations in the Philippines through the lens of PMT. Gaillard (2008) demonstrated that comprehending people's responses to volcanic threats necessitates considering not only volcanic risk perception but also factors unrelated to hazards and structural limitations. Often, researchers have applied their investigations broadly to catastrophic risks, overlooking their distinctions. Bolletino et al. (2020) investigated the interrelation between public understanding of climate change and readiness for disasters, revealing a potentially reciprocal relationship. In contrast, Venable et al (2021) concentrated solely on the indigenous and scientific understanding of housing safety against typhoon winds, specifically focusing on roof and wall structures.

The Theory of Planned Behavior (TPB) serves as a framework for anticipating an individual's actions within specific situations, considering the timing and context. This model builds upon the foundation laid by the Theory of Reasoned Action (TRA) developed by Fishbein and Ajzen (1975). TPB is frequently employed to encompass the range of behaviors individuals undertake to exert self-control. It is a framework employed for anticipating an individual's actions within specific circumstances, timeframes, and locations. It builds upon the foundation of the Theory of Reasoned Action (TRA) formulated by Fishbein and Ajzen (1975). TPB is frequently applied to encompass various behaviors individuals engage in to exercise

self-regulation. TPB was developed for certain situations where people do not have full control over the behavior in question (Ajzen, 2006). According to the TRA, the likelihood of performing a particular behavior increases with the strength of an individual's intention towards it. Notably, the significance of behavioral intention hinges on whether the behavior is entirely within the individual's voluntary control. While certain behaviors can be easily executed based on specific criteria, others necessitate motivational factors such as essential resources and opportunities (Ajzen, 1991). When an individual possesses the requisite opportunities and resources, their intention to engage in a particular behavior becomes more robust, leading to the actual enactment of the behavior.

If the individual has the necessary opportunities and resources, his intention to perform the behavior will be stronger and he will be more likely to perform the behavior. At this point, perceived behavioral control of intention comes into play (Sparks and Shepherd, 1992). To summarize, TPB advances by introducing the element of perceived external control to the factors influencing intention, which in turn impacts behavior.

TPB has been widely used in studies related to different subjects. Moan and Rise (2011) determined to what extent the theory of planned behaviour (TPB) extended with moral and descriptive norm is able to predict intentions not to drink a drive. Jiang et al. (2017) studied factors affecting fatigued driving behavior from the perspective of social psychology. In the same study, the questionnaire was designed based on the theory of planned behaviour.

Structural equation modeling provides a systematic and comprehensive approach to a complex research problem in a single process by modeling the relationships between many dependent and independent variables. Structural equation modeling method is used in testing many theories and developing new models for many reasons such as being successful in testing complex models. Structural equation models are a statistical technique used to test models in which causal relationships and correlation relationships between observed variables and latent variables coexist. This approach is a multivariate technique employed to assess interdependencies among variables, and it is constructed by combining analyses such as variance-covariance analysis, factor analysis, and multiple regression. In the realm of structural equation modeling, the prevalent approach utilized to determine whether the data align with the model is the two-step method (Anderson and David, 1988).

As the first step in the analysis, first the measurement model is tested (Huchting et al, 2008). The process involves a two-step evaluation: first, verifying if the measurements of the constructs within the model accurately capture the intended constructs; second, scrutinizing the structural models themselves. In cases where the researcher lacks precise measurements or the

statements intended to gauge the constructs fail to effectively capture the desired structure, analyzing the structural model becomes futile.

Some researchers combine Protection Motivation Theory and Extended Theory of Planned Behavior. Ong et al. (2021) examined the significant determinants that impact the willingness of Filipinos to prepare for mitigating the effects of "The Big One" earthquake. This was achieved by incorporating both the Protection Motivation Theory and the Extended Theory of Planned Behavior into the analysis. Prasetyo et al. (2020) integrated Protection Motivation Theory (PMT) and extended Theory of Planned Behavior (TPB) to evaluate factors affecting the perceived effectiveness of COVID-19 prevention measures among Filipinos during Enhanced Community Quarantine (ECQ) in Luzon, Philippines. Ng (2022) adopted an extended theory of planned behavior to understand how risk perception affected disaster preparedness behavior. Yılmaz et al (2023) performed the analysis of the effects of the model and the importance performance map on the effect of latent variables using Partial Least Squares Structural Equation Modelling.

This study seeks to bridge this gap by analyzing the role of social media in shaping earthquake awareness, perceived severity, perceived vulnerability, and preparedness behaviors through a structural equation modeling approach. By incorporating PMT and TPB within this framework, the research contributes to a more nuanced understanding of the factors influencing earthquake preparedness and offers valuable insights for developing more effective disaster mitigation strategies.

This study aims to examine the crucial factors influencing the willingness to prepare for potential earthquake mitigation. The research framework presented in the study is constructed by combining the Protection Motivation Theory and the Extended Theory of Planned Behavior. Through the application of Structural Equation Modeling (SEM), various factors including comprehension of earthquakes, perceived vulnerability, perceived severity, subjective norm, perceived behavioral control, attitude, media influence, and intention to prepare have been taken into consideration. The findings of the study can be used by managers to enable them to carry out earthquake preparedness and mitigation practices.

This study aims at filling a research gap by examining the role of social media in earthquake preparedness, an area largely unexplored. Unlike previous studies, it integrates Protection Motivation Theory (PMT) and the Extended Theory of Planned Behavior (TPB) into a comprehensive model. Using PLS-SEM, the findings confirm that earthquake attitude and social media significantly influence preparedness behaviors. The study highlights the need for disaster authorities to leverage social media in raising public awareness, especially in seismically active regions like Turkey. Its novel

approach, strong methodology, and practical implications make it a valuable contribution to disaster preparedness research.

2. Methodology

2.1. Partial Least Squares Structural Equation Modeling

Structural equation modeling is a method that systematically deals with a complex research problem in a single process by modeling the relationships between dependent and independent variables. Structural Equation Model is a statistical methodology utilized to evaluate models containing causal and correlational connections between observed and latent variables. This technique is a multivariate method that is used to estimate dependency relationships and consists of analysis of variance, covariance, factor analysis and multiple regression. Structural equation modeling, which is used to evaluate whether the data support the model, is frequently addressed in the literature (Anderson and David, 1988).

Partial Least Squares were first introduced by Wold in 1982. Subsequently, Wold et al. (1983) used the Partial Least Squares regression model, and Lohmöller (1989) and Tenenhaus et al (2005) introduced the Partial Least Squares Regression Structural Equation Modeling (PLS-SEM) technique. This statistical method is employed to model intricate multivariate associations between observed and latent variables. In cases where it can't be met to provide the assumptions about the normal distribution required in multivariate statistics, a model can be easily created with the help of this method (Vinzi et al., 2010).

Since there is no generally accepted goodness of fit index in the Partial Least Squares Regression Structural Equation Modeling method, model validity and fit are evaluated with factor loads, path coefficients, R^2, f^2 and Q^2 statistics (Kline,2011).

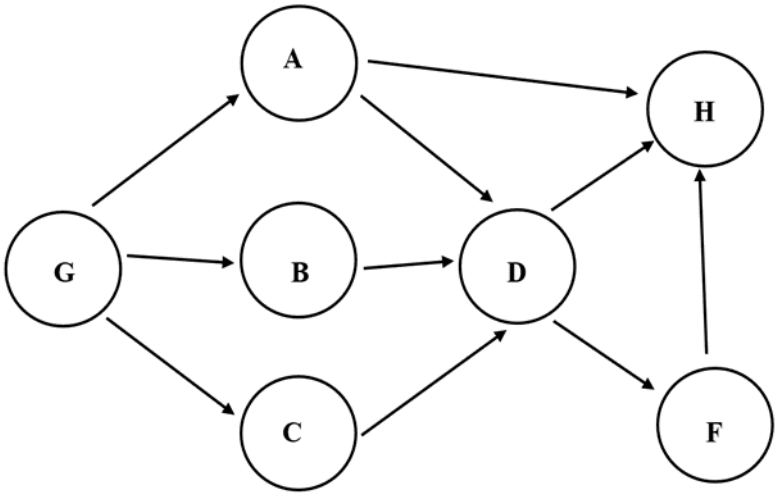
2.2. Research Model and Hypotheses

The research model was created by referring to some earlier studies (Dooley, 1992, Edwards, 1993, Farley et al., 1993, Junn, 1996, Blanchard-Boehm, 1998, Baytiyeh and Naja, 2015, Baytiyeh 2015, Prasetyo et al.,2020, Ong et al.2021) The factors in the research model are as follows.

A: Earthquake Information Awareness
B: Perceived Severity
C: Perceived Vulnerability
D: Earthquake Attitude
F: Intention to Prepare
G: Media Influence

H: Earthquake Preparedness Behavior

The theoretical framework of this study is presented in Figure 1, which depicts the combination of the Theory of Planned Behavior and the Protection Motivation Theory. This figure showcases the research model designed to discern the elements influencing the intention to prepare for mitigating an anticipated earthquake.



A: Earthquake Information Awareness, B: Perceived Severity, C: Perceived Vulnerability, D: Earthquake Attitude, F: Intention to Prepare, G: Media Influence and H: Earthquake Preparedness Behavior.

Figure 1. Research Model

2.2.1. Earthquake Information Awareness

Earthquake information awareness is the general term used for the consciousness that will be created and placed in the minds of people living in the earthquake zone in order to make them realize the reality of earthquakes. Awareness of hazards or preparedness may be triggered by certain information, but as time passes, this awareness may dissipate (Wold, 1982). According to Shapira et al. (2018), there exists a noteworthy connection between hazard awareness and earthquake adaptations. This encompasses the implementation of hazard preparedness measures aimed at bolstering response capabilities. Their research indicated that individuals possessing heightened hazard awareness are more likely to exhibit enhanced earthquake preparedness. This elevated awareness, which prompts individuals to treat a disaster earnestly, contributes to their comprehension of the situation. Consequently, this awareness holds the potential to influence both attitude levels and preparedness behaviors. In the light of this information, the researchers hypothesized that:

H1: Earthquake Information Awareness has a positive and significant impact on Earthquake attitude (H1: A→D).

H2: Earthquake Information Awareness has a positive and significant impact on Earthquake Preparedness Behavior (H2: A→H).

2.2.2. Perceived Severity

Perceived Severity is characterized as the adverse impact of a situation on a person (Miles, 2020). In cases of disasters, it encompasses the evaluation and related thoughts concerning the consequences of a specific disaster. Drawing from the cognitive theory of stress and coping, an individual's experience during a disaster can foster greater fear compared to others, prompting them to become more cautious and ready for similar events in the future (Quan, 2017). The fear that instills a sense of seriousness within individuals can lead to increased awareness, preparedness, and a deeper understanding of the situation. Wu (2020) highlighted that prior research demonstrates a significant association between the perceived severity of a threat and people's compliance with governmental measures, particularly in terms of behavioral control. Additionally, perceived severity was identified as a key determinant of human behavior throughout pandemics (Laato et al., 2020). Based on Yeung and Morris (2001), some scholars argued that subjective norms influence perceived severity, subsequently indirectly affecting people's attitudes and behavior. The results of a meta-analysis studied by Zhao et al. (2018) revealed in conjunction with certain factors, perceived severity exerts a substantial impact on attitudes. Atei et al. (2021) claimed that perceived severity has a significant effect on farmers' intention to use green pesticides. Taking these factors into account, the following hypothesis has been formulated:

H3: Perceived Severity of the Earthquake Awareness has a positive and significant impact on Earthquake attitude (H3: B→D).

2.2.3. Perceived Vulnerability

Despite numerous studies on vulnerability conducted in the past couple of decades, there remains a scarcity of information concerning the interconnectedness among the various dimensions of vulnerability to natural hazards (Prasetyo et al., 2020). Perceived Vulnerability pertains to the faith of people in the potential to suffer harm in a circumstance, be it mentally, physically, or emotionally (Gerrard, 2020). Weinstein (1998) articulated that a person progresses through distinct phases of recognizing their vulnerability, moving from a lack of awareness to acknowledging the peril, and eventually comprehending their personal risk. Acknowledging the potential catastrophic risk could empower individuals to broaden their knowledge and

understanding, consequently averting the occurrence of the danger (De Coninck, et al., 2020). Therefore, the researchers postulated that:

H4: Perceived Vulnerability has a positive and significant impact on Earthquake attitude (H4: C→D).

2.2.4. Earthquake Attitude

According to Wang et al. (2020), attitude is a cognitive state that reflects an individual's perception of people, places, objects, or events. It has a great influence on people's behavior and thought processes. The theory of planned behavior elucidates how attitude functions as one of the precursors that interfere with the motive to engage in a particular behavior. In the research conducted by Aboelmaged (2021), it was established that attitude significantly impacts the intention of young consumers to recycle e-waste. Moreover, Ataei et al. (2021) revealed that the tendency to adopt environmentally friendly pesticides is affected by one's attitude towards preventing health and illness. Similarly, within the domain of catastrophe preparedness, research has emphasized the relationship between attitude and the motivation to prepare for emergencies. Hoffman and Muttarak (2017) assert that an individual's attitude regarding risk in catastrophic disaster scenarios may impact their decision to take preventive actions. The attitude factor, which was expressed as attitude in the previous models, was changed to Earthquake attitude since the items used in this model were taken into account.Hence, this was hypothesized:

H5: Earthquake attitude has a positive and significant impact on Earthquake Preparedness Intent (H5: D→F).

H6: Earthquake attitude has a positive and significant impact on Earthquake Preparedness Behavior (H6: D→H).

2.2.5. Intention to Prepare

Disaster preparedness is an ongoing endeavor that unfolds prior to the onset of a disaster. It equips individuals, communities, and organizations to respond with greater efficiency and recover swiftly when confronted with a disaster. The overarching goals of disaster preparedness encompass heightening safety, refining response efforts, and bolstering the adaptive and resilient capabilities of individuals and communities. Researchers have endeavored to elucidate and assess the motivations of individuals within susceptible communities with regard to their readiness for earthquake hazards. The outcomes unveiled a subpar state of earthquake preparedness. Moreover, through multiple regression analysis, it was observed that higher educational institutions exerted an insignificant influence on achieving the

requisite level of preparedness among students (Hoda and Naja, 2015). The researcher hypothesized that:

H7: Earthquake Preparedness Intent has a positive and significant impact on Earthquake Preparedness Behavior (H7: F→H).

2.2.6. Media Influence

Guo et al. (2020) employed social media and alternative communication channels to disseminate information about suitable preparedness measures for households concerning catastrophe. Additionally, Kirschenbaum et al. (2017) investigated the role of media as a conduit for disaster connections, examining its potential influence on people's attitudes towards disaster preparedness. It has been observed that media serves as a platform for vicarious experiences, which in turn stimulates discussions on hazard preparedness among individuals (Becker et al., 2017). Gerhold et al. (2019) noted that risks perceived as uncertain are distinct from those that have been clearly identified through media exposure or personal encounters. The increased coverage of disasters and preparedness in mass media influences public attention. Exposure to media reports on disasters and preparedness can facilitate the integration of disaster awareness into everyday social conversations (Becker et al., 2017). Consequently, the impact of social media can reshape individuals' perceptions of response and actual preparedness (Kirschenbaum et al., 2017). Therefore, the following three hypotheses have been put forward by the authors.

H8: Media Influence has a positive and significant impact on Earthquake Information Awareness (H8: G→A).

H9: Media Influence has a positive and significant impact on Perceived Severity of the Earthquake (H9: G→B).

H10: Media Influence has a positive and significant impact on Perceived Vulnerability (H10: G→C).

2.3. Questionnaire and Participants

The lack of studies on preparedness for possible major earthquakes has revealed the necessity of investigating preparedness and disaster mitigation. This study is focused on investigating the key determinants influencing individuals' intent to prepare for potential earthquake mitigation. The research framework employed in this study integrates the Protection Motivation Theory and the Extended Planned Behavior Theory. To analyze the research model and validate the hypotheses, the Partial Least Squares Structural Equation Modeling technique was utilized. The outcomes of this study hold potential utility for managers, aiding them in implementing effective earthquake preparedness and mitigation measures.

This survey is an academic study conducted to investigate the intentions and behaviors of people to prepare for the mitigation of the possible effects of an expected earthquake. The data used in the study were compiled in June 2022 via the online form. The questionnaires were completed by 257 volunteer participants with digital access to data collection tools. When the data were examined, it was determined that the answers of 2 questionnaires were not consistent and analyzes were made with the data obtained from 255 participants. In the first part of the questionnaire, there are 5 questions to measure demographic characteristics and 4 questions about earthquake awareness. In the second part, there are 41 items that refer to the "0-strongly disagree" and "10-strongly agree" measures to measure attitudes. These items are related to earthquake awareness, perceived vulnerability, perceived severity, subjective norm, perceived behavioral control, attitude, media attention, and preparedness intention. In the third part of the questionnaire, there are 10 more questions in the form of yes, no and partially about earthquake preparedness behavior.

For structural equation models, the priori sample size can be calculated by considering the number of observed and latent variables in the model, the expected effect size, significance level, and statistical power levels (Wolf et al., 2013, Soper, 2018). In the study, the desired statistical power level was 0.75. There were a total of 7 latent variables, 50 observed variables, and a minimum sample size of 237 at the 5% significance level. For this reason, the sample size used in the study, n=255, was considered sufficient.

This survey is an academic study conducted to investigate the intentions and behaviors of people to prepare for the mitigation of the possible effects of an expected earthquake. The characteristics of the participants are presented in Table 1.

Table 1. Descriptive Characteristics of the participants (n=257)

Charecterics	**Category**	**Frequency (N)**	**%**
Gender	Male	130	50,4
	Female	157	49,6
Age	15–24	38	14,8
	25-34	47	18,3
	35-44	62	24,1
	45-54	58	22,6
	55-64	51	19,8
	More than 65	1	,4

Education	High school graduate	7	2,7
	University student	36	14
	Graduate	95	37
	Postgraduate	113	44
City	Eskişehir	40	15,6
	İstanbul	38	14,8
	Ankara	21	8,2
	Kahramanmaraş	18	7
	Mersin	18	7
	Bursa	16	6,2
	Adana	14	5,4
	Other	41	35,8

According to the Table 1, there are 127 female and 130 male participants. If we express it as a percentage, there are 49.4% women and 50.4% men. When the age ranges are examined, it is seen that the sample is adjusted to come close to each range. Considering the education level of the participants, it was observed that the majority of them were university graduates (37%) and postgraduates (44%). The online survey was conducted in the most populous cities of the country. 15.6% of the participants are from Eskişehir40, 14.8% from İstanbul38, 8.2% from Ankara21, 7 from Kahramanmaraş18, 7% form Mersin18 6.2% from Bursa16, 5.4% from Adana and 35.8% from 41 other cities.

3. Results

3.1. Evaluation of the Structural Model

Analysis results regarding the structural model are given in Figure 2. In Figure 2, the path coefficients between the factors and the factor loads of the items belonging to each factor are given.

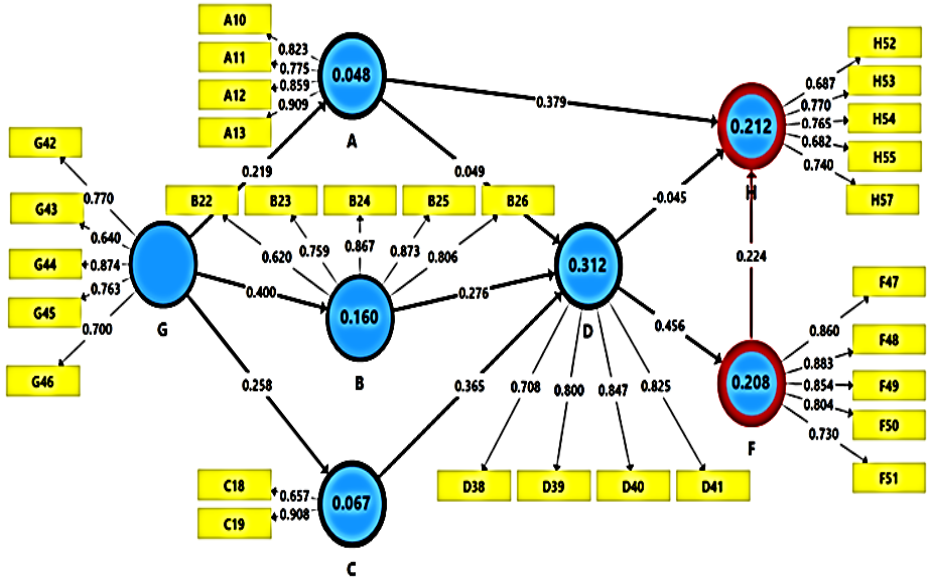


Figure 2. Empirical PLS-SEM

While examining the structural model, the coefficient of determination R^2, the effect size f^2, the path coefficient and t-value, the validity of the estimator Q^2 and the goodness of fit values are considered. For model fit, the measures calculated in the Smart-PLS 3 software are Standardized Root Mean Square Residual (SRMR) and Normed Fit Index (NFI) value (Yılmaz and Kinaş, 2020).

The model is said to be suitable when the difference between the correlation matrix of the model and the empirical correlation matrix is statistically insignificant ($p>0.05$). Otherwise, model fit cannot be determined.

In order for the model to have an acceptable fit, the SRMR value is required to be less than 0.10. The SRMR value for the model was calculated as 0.080. The values of 2.972 and 0.789 calculated for the d_ULS and d_G full compliance criteria were found to be $p > 0.05$. The chi-square value is 1161.389. NFI value is required to take values between 0 and 1. The NFI value close to 1 indicates that the model has a good fit. The NFI for the model in the study was calculated as 0.958.

When the structural model results were examined, VIF values were calculated as $1.0<VIF<1.287$. Since the values are less than 5, there is no multicollinearity problem between the factors.

3.2. Path Coefficients and Hypothesis Testing

The results calculated using the Smart PLS 3 software are given in Table 2. In Table 2, path coefficients showing cause and effect relationships, *t* values showing the significance of factor loads and impact measure f^2 are seen.

Table 2. Hypothesis testing results

Hypothesis	Path coefficients	t-values	p-values	Decision	f^2
A→D	0,049	0,604	0,546	Not supported	Low
A→H	0,380	7,479	P<0,01	Supported	Medium
B→D	0,275	3,373	P<0,01	Supported	Low
C→D	0,365	4,802	P<0,01	Supported	Medium
D→F	0,458	7,569	P<0,01	Supported	High
D→H	-0,043	0,705	0,481	Not supported	Low
F→H	0,223	3,468	P<0,01	Supported	Low
G→A	0,219	2,761	P<0,01	Supported	Low
G→B	0,400	7,073	P<0,01	Supported	High
G→C	0,258	3,835	P<0,01	Supported	Medium

A: Earthquake Knowledge-Awareness; B: Perceived Severity of the Earthquake, C: Perceived Vulnerability; D: Earthquake attitude;

F: Earthquake Preparedness Intent; G: Media Influence; H: Earthquake Preparedness Behavior

When Table 2 is examined, it has been determined that the largest coefficient is between earthquake attitude and earthquake preparedness intention (D→F: 0.458). According to this coefficient, it means that as the earthquake attitude increases, the intention to prepare for the earthquake will increase. The second coefficient is the effect of social media on the perceived severity of the earthquake (G→B: 0.400). With the help of this value, it can be said that as the effect of social media increases, the perceived importance of people towards earthquakes will also increase. The third important safe is about the awareness of the earthquake and the measures taken in the houses to reduce the effects of the earthquake (A→H: 0.380). It has been understood that as earthquake knowledge-awareness increases, the precautionary

behaviors of people in houses to reduce the effects of earthquakes will also increase. Finally, it addresses earthquake attitude with the perceived vulnerability. It has been revealed that the greater the perceived vulnerability, the greater the earthquake attitude (C→D: 0.365).

Social media has a significant positive effect on the perceived severity of the earthquake. A unit increase in the social media influence of individuals is causing the perceived severity to increase by 0.400 units (G→B: 0.400; t=7.073;p<0.01).

Social media significantly positively affected the perceived vulnerability of the earthquake. A unit increase in the social media influence of individuals is causing the perceived vulnerability to increase by 0.258 units (G→C: 0.258; t=3.835;p<0.01).

In addition, it was revealed that awareness of earthquake information significantly affected the earthquake preparedness behavior, and a one-unit increase in earthquake awareness increased the earthquake preparedness by 0.380 units. Considering that awareness of earthquake information is also significantly affected by social media, it can be evaluated that social media positively affects earthquake preparedness intentions and behaviors. It can be stated that social media is an important power of information and awareness, and it is a useful tool in raising knowledge and awareness in the development of earthquake preparedness behaviors.

Table 3. Significant indirect effects

	Path coefficients	t-values	p-values
G→B→D	0,110	2,767	0,006
G→C→D	0,094	2,506	0,012
B→D→F	0,126	2,995	0,003
G→B→D→F	0,050	2,499	0,012
C→D→F	0,167	3,691	0,001
G→C→D→F	0,043	2,151	0,031
G→A→H	0,083	2,539	0,011
B→D→F→H	0,028	2,261	0,024
G→B→D→F→H	0,011	1,988	0,047
D→F→H	0,102	3,167	0,002
C→D→F→H	0,037	2,366	0,018

According to Table 3, it has been revealed that the effect of social media indirectly affects the preparedness attitudes, intentions and behaviors towards earthquakes in residences.

3.3. Multiple Group Analyses

In this study, a multiple group analysis for the income was performed, and the results are given in Table 4. Grouped as Gr1- My income does not meet my expenses, Gr2- My income meet my expenses. Perceived earthquake attitude → Earthquake preparedness behavior (gr1-gr2): -0.241 (p=0.036) This finding means that the gr1 group is more concerned about earthquakes than the gr2 group.

Table 4. Bootstrapping Results

	Path Coefficients (gr1)	**Path Coefficients (gr2)**	**p-Value (gr1)**	**p-Value (gr2)**
A→D	0,004	0,125	0,487	0,102
A→H	0,381	0,408	P<0,01	P<0,01
B→D	0,328	0,278	0,044	P<0,01
C→D	0,296	0,376	0,030	P<0,01
D→F	0,467	0,459	P<0,01	P<0,01
D→H	-0,235	0,006	0,019	0,468
F→H	0,343	0,180	0,002	0,011
G→A	0,358	0,167	0,001	0,033
G→B	0,401	0,419	0,001	P<0,01
G→C	0,247	0,273	0,078	P<0,01

As previously mentioned, there exists a notable relationship between the perceived attitude related to earthquakes and the intentions to mitigate the impact of earthquakes. This relationship also revealed gender differences. A negative difference means that men are more worried about earthquakes than women. However, it has been revealed that they intend to take action to reduce the effects of earthquakes in residences.

3.4. Validity of the Model

Table 5 presents the Composite Reliability (CR) and the values Average Variance Extracted (AVE) representing internal consistency and convergent validity of the latent. Three criteria are employed to ascertain the validity of the model: Firstly, the standardized factor load of the observed variables associated with latent variables must exceed 0.50 and be statistically significant (Fornell and Larcker, 1981), secondly the Composite Reliability and Cronbach Alpha values of the variables are greater than 0.70 (Hair et al. 1998), and thirdly the AVE value of the latent variables is greater than 0.50 (Fornell and Larcker, 1981).

Table 5. Construct reliability and validity of the measurement model

	Composite Reliability (CR)	**Average Variance Extracted (AVE)**
A	0,907	0,710
B	0,891	0,625
C	0,767	0,627
D	0,874	0,635
F	0,916	0,686
G	0,867	0,568
H	0,850	0,532

When Table 5 is examined, the validity of the model was examined by considering these 3 criteria. It is seen that the structural reliability (CR) coefficients are greater than 0.70 for all factors and the AVE values are greater than 0.50. To gain a deeper understanding of construct validity, Hair et al. (2014) proposed the utilization of the Fornell-Larcker Criterion for testing discriminant validity. The Fornell-Larcker Criterion is a widely used approach to assess the discriminant validity of measurement models. According to this criterion, the square root of the average variance extracted by a construct should be greater than the correlation between that construct and any other construct. This criterion adopts a cautious approach to assess the correlation between constructs against the square root of the value of AVE for each latent variable. Table 3 displays the outcomes of the Fornell-Larcker Criterion. Notably, the diagonal values (highlighted in bold) surpass the

off-diagonal values. This affirmation underscores the credibility of the measurements (Yang et al., 2020).

Table 6. Discriminant validity -Fornell-Larcker criterion

	A	B	C	D	F	G	H
A	0,843						
B	0,153	0,790					
C	0,062	0,471	0,792				
D	0,114	0,455	0,497	0,797			
F	0,173	0,297	0,226	0,456	0,828		
G	0,219	0,400	0,258	0,406	0,517	0,754	
H	0,413	-0,043	-0,013	0,101	0,269	0,136	0,730

Furthermore, for evaluating discriminant validity, the Heterotrait-Monotrait (HTMT) Ratio can also be employed. This approach utilizes a correlation method based on Monte Carlo Simulation to assess the constructs within this study. According to this criterion, HTMT expresses the ratio of the mean of the correlations of the expressions of all the variables in the study to the geometric means of the correlations of the expressions of the same variable. HTMT values are given in Table 7.

Table 7. Discriminant validity -HTMT criterion

	A	B	C	D	F	G	H
A							
B	0,188						
C	0,286	0,834					
D	0,161	0,556	0,797				
F	0,198	0,341	0,325	0,531			
G	0,239	0,473	0,395	0,493	0,617		
H	0,487	0,106	0,092	0,148	0,327	0,188	

When the values in Table 7 are examined, the HTMT values observed are found to be below the specified threshold. The established thresholds for HTMT are typically set at 0.850 (Kline, 2011) and 0.900 (Hair

et al., 2014). As demonstrated in Table 7, the HTMT Ratios for the relationships exhibit values that are lower than 0.85. This indicates that the results for the interrelationships among the constructs are within an acceptable range.

4. Discussions and Conclusions

Despite the frequent occurrence of catastrophic earthquakes in seismically active regions such as Turkey, research on earthquake preparedness and mitigation remains insufficient. Previous studies have predominantly examined general risk perception, disaster response, and broad applications of theories such as the Protection Motivation Theory (PMT) and the Extended Theory of Planned Behavior (TPB), often without integrating them specifically within the context of earthquake preparedness. Furthermore, while social media has been acknowledged as a crucial medium for risk communication, its specific influence on earthquake preparedness behaviors and attitudes has not been comprehensively investigated.

This research aims to address this deficiency by examining how social media influences earthquake awareness, perceived risk, vulnerability, and preparedness behaviors using a structural equation modeling approach. By integrating the Protection Motivation Theory (PMT) and the Theory of Planned Behavior (TPB) within this model, the study provides a deeper insight into the determinants of earthquake preparedness and offers practical recommendations for enhancing disaster mitigation strategies.

The research analyzed 257 accurate replies from Turkey to evaluate the intention to prepare. Seven latent variables were evaluated which are A: Earthquake Information Awareness, B: Perceived Severity, C: Perceived Vulnerability, D: Earthquake Attitude, F: Intention to Prepare, G: Media Influence, H: Earthquake Preparedness Behavior

With the help of Structural Equation Modelling (SEM), it is concluded that Earthquake Attitude, Media, Earthquake Information Awareness are key factors affecting the intention of the people to prepare for an expected Earthquake.

According to the results obtained, it has been determined that the largest coefficient is between earthquake attitude and earthquake preparedness intention (D→F: 0.458). This coefficient indicates that as earthquake attitude increases, the intention to prepare for an earthquake also increases."

Factors such as concern about earthquake effects, stress over a potential major earthquake, worry for family safety, and the belief that one's city will be affected were identified as key drivers of the intention to prepare. This aligns with various other studies (Savari and Gharechaee, 2020, Ong et al., 2021, Ataei et al., 2021, Aboelmaged, 2021) that have highlighted the substantial influence of attitude on individuals' behavioral intentions.

The second coefficient is the effect of social media on the perceived severity of the earthquake (G→B: 0,400). The Social Media latent variable was observed to hold significance, which corresponds with findings from Ong et al. (2021) and Gerhold et al. (2019), where it was noted that risks are perceived differently when communicated through media sources. Additionally, media reports and sources have been demonstrated to impact people's faiths and levels of attitude regarding catastrophe (Becker et al., 2017). Furthermore, media attention has been linked to eliciting negative emotions concerning earthquakes (Van der Voort and Vanclay, 2014).

The third important safe is about the awareness of the earthquake and the measures taken in the houses to reduce the effects of the earthquake (A→H: 0.380). It has been understood that as earthquake information awareness increases, the earthquake preparedness behaviors of people in houses to reduce the effects of earthquakes will also increase. The results are consistent with various studies (Wold, 1982, Miles, 2020).

Finally, it addresses earthquake attitude with the perceived vulnerability. It has been revealed that the greater the perceived vulnerability, the greater the earthquake attitude (C→D: 0.365). Lam (2006) determined that perceived vulnerability increases the motivation to execute health behaviors. This finding can also be supported by Garcia et al. (2018).

Social media has a significant positive effect on the perceived severity of the earthquake. (G→B: 0.400; $t=7.073$;$p<0.01$) Perceived severity pertains to how individuals perceive the expected earthquake as a substantial threat with the potential to have long-lasting economic impacts. This perception encompasses the potential for casualties and property damage. This notion finds support in the research conducted by Ong et al. (2021) and Zhao et al. (2018) which states that Perceived Severity, can affect the attitude of an individual. Social media also significantly positively affected the perceived vulnerability of the earthquake. (G→C: 0.258; $t=3.835$;$p<0.01$)

In addition, it was revealed that awareness of earthquake information significantly affected the earthquake preparedness behavior, and a one-unit

increase in earthquake awareness increased the earthquake preparedness by 0.380 units. Considering that awareness of earthquake information is also significantly affected by social media, it can be evaluated that social media positively affects earthquake preparedness intentions and behaviors. It can be stated that social media is an important power of information and awareness, and it is a useful tool in raising knowledge and awareness in the development of earthquake preparedness behaviors.

This study highlights the policy significance of leveraging social media to enhance earthquake preparedness by shaping public awareness, perceived severity, and vulnerability. Findings suggest that disaster authorities should integrate social media into risk communication strategies, ensuring timely and reliable information dissemination. Targeted educational campaigns should focus on fostering proactive attitudes toward earthquake readiness, emphasizing real risks and mitigation behaviors. Policies should also encourage community-based preparedness programs, stricter building regulations, and financial incentives for structural safety improvements.

It is recommended that efforts to enhance earthquake preparedness in Turkey should encompass actions taken before, during, and after an earthquake. Raising awareness about the potential dangers and casualties associated with earthquakes is crucial, as it significantly influences individuals' readiness to prepare for such events. Given the considerable influence of media on attitudes, utilizing media platforms becomes essential for informing people about strategies to potentially mitigate the impact of anticipated earthquakes.

Due to the limitations of the pandemic, a face-to-face survey could not be conducted in the study. Considering the low response rates in online surveys, the number of questions has been kept low in order to avoid biased and inconsistent answers. The authors of the present study recognize that they did not gather information about the respondents' mandatory earthquake insurance during the administration of the online survey. Consequently, having compulsory earthquake insurance has caused to various consequences as it might change the certain factors' weight. This study can also be carried out for the expected Istanbul earthquake by collecting data only from the province of Istanbul. These may be an area that future researchers can focus on.

Declaration of competing interest

The authors assert that they do not possess any identifiable conflicting financial interests or personal affiliations that could potentially be perceived as influencing the findings presented in this study.

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