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INTEGRATING ENGINEERING AND SUSTAINABLE ACCOUNTING TO ACHIEVE ENVIRONMENTAL SUSTAINABILITY: AN APPLIED STUDY OF IRAQI OIL COMPANIES

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Abstract:

This research seeks to establish how engineering activities can be incorporated with sustainable accounting into Iraqi oil firms to improve the environmental and accounting aspects. Analyzing both quantitative and qualitative data, the study quantitatively investigates the effectiveness of this integration while qualitatively examining the perceptions of this integration through a case study. There is a mixed relationship between the integration of the engineering data and the perceived benefits based on the quantitative data and qualitative responses regarding its contribution to sustainability initiatives and decision-making, for which there is a positive perception, albeit due to a limited quantitative statistical influence of the demographic variables. The study lays down enormous future consequences for the oil sector. It indicates that properly integrating engineering and accounting disciplines can revolutionize environmental policies and enhance financial reporting techniques. These insights call for optimizing the current business practices to maximize the benefits of integrating engineering and accounting for the conservation of the environment and enhancing economic performance.

Keywords: Engineering accounting, Sustainable accounting, Environmental cost accounting, Environmental sustainability, Oil industry practices, Engineering data integration.

INTRODUCTION

The oil industry is a critical player in energy provision worldwide and, simultaneously, a significant culprit in environmental pollution, especially in countries like Iraq, where oil exploration and refining occurs. Environmental impacts are also a significant problem in this industry, including pollution, emissions of greenhouse gases, and other vices unfavorable to both the ecosystem and human health as well as the socio-economic development of the society. These exigent environmental concerns call for creative approaches beyond conventional methods (Almagtome et al., 2020).

Engineering accounting is a new concept that brings the engineering concept with the best accounting to capture the costs and impacts on the environment. It is a valuable means of aiding oil companies in determining and managing their environmental costs and risks with less probability. Engineering accounting contributes to corporate sustainability, which has become the decisive point for the evolution of the environmentally responsible approach and the disclosure of the work processes.

While discussing engineering accounting, it is possible to discuss the concept's relevance to Iraqi oil companies. This paper gives the context needed to comprehend the environmental and socio-political issues in Iraq, a nation with one of the world's largest oil deposits, which only worsens the consequences of the oil sector. In this regard, through engineering accounting practices, the Iraqi oil companies should be able to practice sustainability first and thus act as a model to other companies in the region and the world over (Alnoor et al., 2024). It is helpful to appraise the environmental cost better, which enhances the investment and policy-making process and raises awareness about sustainability to receive more economic and ecological benefits in the future. This change emphasizes the importance of engineering accounting in bringing a positive change in the sustainability practices in the oil industry; thus, it qualifies it as an innovation for sustainable management of the environment in Iraq and other similar environments in the world.

LITERATURE REVIEW

Engineering accounting, which is the application of engineering principles into accounting, is gradually gaining acceptance as a powerful tool in fighting environmental issues. This new interdisciplinarity is especially valuable in industries with significant environmental impacts and when effects are easily reducible to a measurable value, such as the oil industry. For instance, Andersen & Gulbrandsen (2020) have attempted to shift the center toward the part that

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engineering data can play to enhance the current accounting models and address the environmental costs of industries. These studies stress that through engineering accounting, it becomes possible to obtain a better understanding of the consumption of resources, disposal of wastes, and improvements in the reduction of emissions as technical information is put into the financial context.

The following literature review suggests that there is still a significant research gap that needs to be filled in order to enhance the enforcement of sustainable accounting practices, particularly within the oil industry. Sustainability accounting is created to consider environmental and social factors in accounting and financial reporting. Cuckston (2018), in a study, identified that while some of the oil companies have incorporated CSR practices, more vital needs to be fulfilled in implementing sustainability reports. Pollution accounting and environmental reporting are the two fields that should be more advanced and studied to provide the correct information on companies' environmental impact.

This gap is best explained when taking into account pollution accounting practices. Most oil companies are still employing conventional financial accounting methods that do not reveal the true cost of pollution. For instance, Ebaid (2022) has highlighted examples of emissions manipulation and shifting environmental cleanup costs. Such practices not only influence perceptions of society but also undermine good governance of the environment. Environmental reporting is typically limited in giving decision-makers a complete picture of the environmental consequences of business operations, including ecological systems degradation or the secondary effects on species diversity.

These gaps call for the need for this study. Despite the possibility of integrating engineering data into accounting practices as postured in the literature, little research has been done on how the integration of the two can be achieved in the Iraqi oil industry, an essential economic sector characterized by environmental impacts. This research fills these gaps by comprehensively analyzing how engineering accounting can be deployed and adapted within Iraqi oil organizations to improve their environmental disclosure and sustainable development policies (Alshehhi et al., 2018). It aims to add to the discussions on sustainable development in the oil industry context and to propose a realistic and efficient way of enhancing the precision, openness, and accountability of companies' actions in environmental management.

RESEARCH OBJECTIVES AND QUESTIONS

- **Objectives:** Define the aim to develop methodologies that integrate engineering with accounting for better environmental impact management.
- **Research Questions:**
  - How can engineering insights improve the precision of environmental cost accounting?
  - What role does engineering accounting play in the transparency and efficacy of environmental impact reporting?

RESEARCH METHODOLOGY

This research uses a mixed-method approach to ensure that the analysis of adopting engineering and sustainable accounting principles among Iraqi oil firms meets the depth and width of the research questions set (Bridge et al., 2018). The research method encompasses both quantitative and qualitative data collection and analysis, giving a rich framework with both strengths.

Quantitative Research: This work's quantitative part is based on a data set containing 100 rows of data obtained from different P&F sections of the Iraqi oil companies under study. Such information may comprise data on emissions, waste disposal, resource consumption, and financial costs of environmental protection. The quantitative research method will be used to analyze the data using SPSS, and the results will be presented as regression analysis, ANOVA, and correlation to reveal the relationship and the effects of integrating engineering data into accounting practice(Fethi & Rahuma, 2020). The results will aid in realizing the numerical values and trends that come up when the integration is done.

Qualitative Research: Qualitative analysis is also carried out in the study, and this part of the study involved three interviews with senior accountants and environmental engineers working in the oil sector. These interviews should be conducted to gain more profound qualitative data about the real-life issues, advantages, and managerial consequences of applying engineering accounting. Thematic analysis will be applied to analyze the data, and the responses will be coded to reveal perceptions, experiences, and potential solutions regarding sustainability reporting.

DATA COLLECTION AND ANALYSIS

Data Types

The research employs primary and secondary data collection methods to capture the essence of integrating engineering with sustainable accounting practices in Iraqi oil firms.

Quantitative Data: These are production performance indicators like emissions, resource consumption, waste management data, and all financial data related to environmental management activities. This data is collected from the internal reports of the oil companies as these are factual and numerical and used for statistical analysis. To put a

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figure to the environmental effects and the economic cost of their operations, a dataset of 100 rows containing different companies and their departments and functions will be employed (Haque & Ntim, 2018).

Qualitative Data: Semi-structured interviews are conducted with senior accountants and environmental engineers to understand the situation in-depth. These interviews are intended to probe into the qualitative aspects of the respondents' experiences, beliefs, and sentiments about engineering accounting practices. Primary data includes policies, sustainability reports, and compliance records for exploring the existence of frameworks and the environment in which accounting takes place.

Data Analysis

Quantitative Analysis: The study will use several statistical methods in the SPSS software to analyze the quantitative data. The analysis will begin with measuring the essential data characteristics or descriptive statistics to reveal some features of the distribution and the data central tendencies. Propositions will be formulated and analyzed, and a correlation between engineering practices and sustainable accounting will be established using regression analysis and ANOVA. This phase aims to confirm the effectiveness of all the integrated practices quantitatively.

Qualitative Analysis: Interviews and the documents' review will involve a thematic analysis of the transcripts. This method involves partitioning data into themes that are representative of the information that has been gathered. Using the framework will assist in comparing and contrasting the perceptions about integrating engineering concepts in accounting. These practices will be understood using the thematic framework created to determine how they are perceived and put into practice within the organizational culture of Iraqi oil companies (Ibrahim et al., 2019).

These methods combined will offer an all-rounded approach to identifying the current status and the possibility of improvement in engineering accounting for environmental sustainability in the oil sector. This double method helps to make the analysis based on the collected material evidence and supplemented by information from within the industry.

RESULTS

Quantitative Analysis

Correlations Analysis

The correlation matrix reveals several interesting insights into the relationships between various factors related to integrating engineering and sustainable accounting practices. Most correlations appear non-significant, suggesting limited linear relationships between these factors within the dataset. A notable exception is the correlation between understanding how engineering data can be integrated into financial reporting and the belief that this integration helps in making better financial decisions regarding environmental management, which is significant ($r = -0.241$, $p = 0.016$). This suggests a negative relationship, indicating that greater understanding may be associated with less belief in the benefits, possibly reflecting a realistic perspective on the challenges involved (Kamble et al., 2018).

Table 1: Correlations Analysis

Correlations										
		Position	**Department**	**Years of Experience in the Oil Industry**	**I am aware of the principles of sustainable accounting**	**I understand how engineering data can be integrated into financial reporting**	**My company currently integrates engineering data with financial accounting practices**	**There are established protocols for environmental cost tracking and reporting in my department**	**Integrating engineering data into accounting would improve environmental sustainability**	**I believe that this integration would help in making better financial decisions regarding environmental management**
Position	**Pearson Correlation**	1	-.136	.029	-.043	.077	.083	.027	.041	-.048

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	Sig. (2-tailed)		.176	.773	.669	.447	.414	.789	.686	.634
	N	100	100	100	100	100	100	100	100	100
Department	**Pearson Correlation**	-.136	1	-.050	.008	.142	-.152	-.150	.063	.094
	Sig. (2-tailed)	.176		.624	.933	.160	.131	.137	.532	.350
	N	100	100	100	100	100	100	100	100	100
Years of Experience in the Oil Industry	**Pearson Correlation**	.029	-.050	1	-.027	-.035	.087	.088	-.105	-.125
	Sig. (2-tailed)	.773	.624		.792	.732	.389	.383	.297	.215
	N	100	100	100	100	100	100	100	100	100
I am aware of the principles of sustainable accounting	**Pearson Correlation**	-.043	.008	-.027	1	.139	-.051	.024	.062	.032
	Sig. (2-tailed)	.669	.933	.792		.168	.617	.809	.540	.750
	N	100	100	100	100	100	100	100	100	100
I understand how engineering data can be integrated into financial reporting	**Pearson Correlation**	.077	.142	-.035	.139	1	.056	.084	-.113	-.241*
	Sig. (2-tailed)	.447	.160	.732	.168		.581	.407	.262	.016
	N	100	100	100	100	100	100	100	100	100
My company currently integrates engineering data with financial accounting practices	**Pearson Correlation**	.083	-.152	.087	-.051	.056	1	.007	.066	-.052
	Sig. (2-tailed)	.414	.131	.389	.617	.581		.943	.513	.605
	N	100	100	100	100	100	100	100	100	100
There are established protocols for environ	**Pearson Correlation**	.027	-.150	.088	.024	.084	.007	1	-.086	.023
	Sig. (2-tailed)	.789	.137	.383	.809	.407	.943		.395	.822
	N	100	100	100	100	100	100	100	100	100

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mental cost tracking and reporting in my department										
Integrating engineering data into accounting would improve environmental sustainability	**Pearson Correlation**	.041	.063	-.105	.062	-.113	.066	-.086	1	.089
	Sig. (2-tailed)	.686	.532	.297	.540	.262	.513	.395		.379
	N	100	100	100	100	100	100	100	100	100
I believe that this integration would help in making better financial decisions regarding environmental management	**Pearson Correlation**	-.048	.094	-.125	.032	-.241*	-.052	.023	.089	1
	Sig. (2-tailed)	.634	.350	.215	.750	.016	.605	.822	.379	
	N	100	100	100	100	100	100	100	100	100
*. Correlation is significant at the 0.05 level (2-tailed).										

Other correlations, such as the ones between department, position, and years of experience with various measures, show no significant relationships, implying that demographic and positional differences do not significantly influence perceptions and practices regarding sustainable accounting within the context of this dataset. The overall lack of significant correlations might indicate the need for a more nuanced approach to understanding how these factors interact or suggest that other non-measured variables could be influencing these relationships.

Regression Analysis

The regression analysis assesses the influence of demographic variables (Position, Department, Years of Experience in the Oil Industry) on the belief that integrating engineering data into accounting would improve environmental sustainability.

Table 2: Model Summary

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.131[a]	.017	-.014	1.381
a. Predictors: (Constant), Years of Experience in the Oil Industry, Position, Department				

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The results indicate a weak model fit, with an R-square of only 0.017, suggesting that only 1.7% of the variance in the dependent variable is explained by these predictors. The adjusted R-square value is negative (-0.014), which often occurs when the R-square is low, and the model includes multiple predictors. This indicates that the model does not improve predictive accuracy compared to a model without predictors.

Table 3: ANOVA

ANOVA[a]						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	3.204	3	1.068	.560	.643[b]
	Residual	182.986	96	1.906		
	Total	186.190	99			
a. Dependent Variable: Integrating engineering data into accounting would improve environmental sustainability						
b. Predictors: (Constant), Years of Experience in the Oil Industry, Position, Department						

The ANOVA table shows that the regression model is not statistically significant ($F(3, 96) = 0.560$, $p = 0.643$), indicating that, collectively, the variables Position, Department, and Years of Experience do not significantly predict the perceived benefit of integrating engineering data into accounting practices.

Table 4: Coefficients

Coefficients						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	3.044	.572		5.319	.000
	Position	.060	.117	.053	.518	.606
	Department	.079	.124	.065	.639	.525
	Years of Experience in the Oil Industry	-.125	.122	-.104	-1.023	.309
a. Dependent Variable: Integrating engineering data into accounting would improve environmental sustainability						

Individual coefficients for each predictor also show no significant effects. The coefficients suggest minimal influence on beliefs about sustainability improvements, with no p-values approaching significance. This indicates that demographic factors within this sample do not strongly influence perceptions regarding the integration's impact on sustainability. This suggests that other factors not included in the model might be more relevant in explaining these attitudes (Orazalin & Mahmood, 2018).

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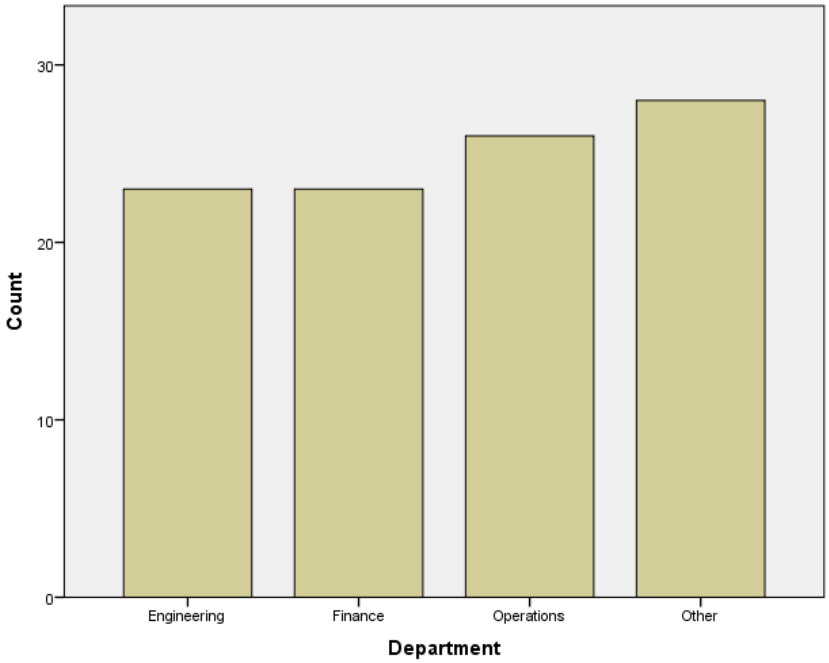

Figure 1: Histogram (Department)

Qualitative Analysis

Theme 1: Awareness and Understanding of Sustainable Practices

It shows the need to be more aware and knowledgeable concerning sustainable practices in different professional capacities. For example, a manager deeply involved in operational oversight stressed the significance of sustainable accounting, indicating a strategic alignment with long-term organizational goals: For example, a manager deeply involved in operational oversight stressed the significance of sustainable accounting, indicating a strategic alignment with long-term organizational goals: "Yes, I have a good understanding of sustainable accounting. It is essential for our long-term goals" (Participant 3). A financial accountant, whose role necessitates a close integration of engineering data and financial practices, confidently asserted their expertise: "I understand it very well; integrating engineering data with financial reporting is a crucial part of my job" (Participant 1). Such statements indicate the basic level of consciousness and highlight the use of such knowledge in improving their work and operational and strategic planning in the company (Kober et al., 2020).

Theme 2: Current Practices and Protocols

This theme focuses on the organization's practices and procedures regarding engineering data and financial accounting. Some practices involve initiating such changes, while others focus on whether these changes will be effective. An Environmental Engineer pointed out the operational reality, stating, "Yes, our company effectively integrates engineering data with financial accounting" (Participant 2). The extent of protocol development varies, with another engineer noting the need for more thorough frameworks: "We do have basic protocols, but they could be more comprehensive" (Participant 2). These findings demonstrate the innovative integration and the areas of improvement that have been realized in the current practices; this shows that there is still room for improvement and innovation to enhance the potential of this integration (O'Dwyer et al., 2019).

Theme 3: Impact on Sustainability and Decision-Making

The third theme focuses on the effects of incorporating engineering data in accounting for environmental sustainability and financial reports. All participants concurred with the fact that this integration has a positive influence on sustainability practices. A Manager in Operations shared, "Absolutely, integrating this data helps enhance our environmental sustainability efforts" (Participant 3). The role of integration in fostering better financial decisions was emphasized, with the same manager highlighting its strategic importance: "It is critical. It allows us to allocate resources more effectively and pursue sustainability objectives with greater financial insight" (Participant 3). These reflections testify that integration positively enhances environmental and financial governance at the company level (Pizzi et al., 2021).

Discussion: 250 words

The study aimed to identify the impacts of integrating engineering discipline in accounting to enhance the development of environmental cost accounting and clarify the environmental impact report. Therefore, quantitative and qualitative

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data provided a better perspective of these research questions (Rentizelas et al., 2020). Quantitative analysis showed a weak and insignificant relationship in correlation and regression analysis tests between the implementation of engineering data and financial practices and factors in the organization. The regression analysis mainly came up with a poor R-squared value, which made it clear that the perceived benefits of this integration are in no way determined by demographic factors such as position, department, and experience in the organization. This implies that although there is some measure and understanding of these practices in the organizations, they are not considered adequate by the demographics in this study. The hypothesis that engineering insights lead to a marked enhancement in the accuracy of environmental cost accounting could not be strongly corroborated (Schroeder et al., 2022).

From the interviews, there are indications of a more positive qualitative outlook, as presented by the following themes. Finally, participants stated that they think integration does enhance work on sustainability and decisions. The theme of "Impact on Sustainability and Decision Making" especially embraced the fact that engineering data integration helps enhance financial decision-making and improve the impacts of sustainability reporting. The importance of integrated data was also acknowledged by participants to give better vision and accountability, which answers the second research question about the role of engineering accounting (Song et al., 2019). While the quantitative evidence is relatively weak, the qualitative findings imply that there is a perceived value among the professions that engineering knowledge can and does improve environmental accounting and reporting practices. These may not necessarily be as quickly numerically quantified in the current structure of organizations or may be affected by other unknown variables.

CONCLUSION AND RECOMMENDATIONS

The research was carried out concerning the implementation of engineering knowledge on how environmental cost accounting and impact reporting within the oil industry. The quantitative results revealed a minimum statistical relation between demographic factors and integration effectiveness perception. Participants expressed positivity on integration as much as it created sustainability and better financial management. This highlights the problem that integration is indeed desired, but this means that its measurable effectiveness may not necessarily be revealed through simple demographic factors, as we see that integration is a rather multifaceted process that must be carried out in practice and within the context of the organization's environment. Based on the insights gathered, several recommendations can be made to oil companies aiming to enhance their environmental and accounting practices: The companies need to acquire better-integrated systems that can link the engineering data with the financial accountancy. This would also help achieve better accuracy in the environmental cost allocation process and increase companies' accountability for the environmental effects they produce (Qian et al., 2021). It may also be helpful to design and present courses for engineers and accountants alike on the significance of integration and the appropriate techniques to apply them. The integration processes should also be reviewed periodically, and improvements made where necessary to counter new challenges or the adoption of new technologies. Implementing these recommendations may ensure that engineering findings are incorporated into accounting frameworks better, enhancing environmental sustainability efforts and financial and environmental accountability.

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