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Investigating the Challenges of Engineering Project Managers in achieving Sustainability in the UK Construction Industry

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Aim: The essential purpose of the current research was to identify the challenges faced by project engineering managers in the UK construction industry while seeking to achieve sustainability.
Study Design: The current study was built upon six important subjects in order to accomplish this goal. In the current study, the researcher opted to do both qualitative and quantitative analysis. The quantitative analysis comprised frequency analysis, correlation analysis, and regression analysis and was based on data collected through questionnaires.
Place and Duration of Study: This study was carried out in Bristol United Kingdom for an investigative period of six (6) Months including the research question distribution and collection time as well as the interview and interaction sections with the Construction Project Engineering Managers.

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Methodology: In light of the nature of the current research, the researcher selected the mixed research design. Mixed research design is the method used to collect data and analyze it using both qualitative and quantitative research methodologies.
Results: The major threats in handling the challenges of Project Engineering Management are; A probability of impact of 59.28% and a level of impact of 40.2% for General Project Management(GPM) and Establishing a Climate of trust (ECT) factors both ranked Cost Class 1, Providing a suitable context for development work (PSCDW) factor was ranked as Cost Class 2 having the percentage of occurrence (51.29%) and level of impact (36.67%) , Providing support within the team (PSWT) factor and Taking Responsibility and ownership (TRO) factor were ranked as Cost Class 4 having percentage of occurrence (40.22% and 36.78%) and level of impact (45.75% and 53%) respectively, it was noted, that GPM and ECT can cause a great threat if ignored during engineering project management procedures.
Conclusion: The study resolved that policies should be put in place to guarantee that advancement in the building sector follows economic integration. It was revealed from the findings of the study that construction is heavily dependent on conventional methods in most rising economies, including the UK, which makes the adoption of novel techniques more challenging and stressful. An important barrier to attaining sustainable construction is clients' and other stakeholders' lack of support for innovative construction techniques.
The findings further revealed that the implementation of eco-friendly building practices by the construction sector has the tendency to reduce an asset's overall environmental impact and promote sustainable economic growth.

Keywords: Sustainability; analytical hierarchy process; engineering project management; construction industry.

1. INTRODUCTION

Cocklin and Moon [1] had opined that policy styles and cultures are varied and range over a spectrum from strong to supportive and from pre-emptive to reactive and are manifested in the extent to which environmental policy can be characterized as "government" or "governance". Furthermore, the policy-makers have the liberty to select from the array of policy tools or instruments for the achievement of objectives related to sustainability; the main categories of which are recognized as regulatory, and market-based, voluntary or information-based, while an effective policy design is characterised by the application of a suitable mix of policy instruments.

The study of Barbosa et al. [2] reveals that the construction industry has an increased responsibility toward society for the reduction of the damage caused by its projects to the social environment. In the UK this has resulted in the requirement for a sustainable project standards for all the projects that have been widely established [3]. However, the organizations in the construction industry have been observed to be facing increased challenges in incorporating social, economic as well as environmental responsibility in their tactical business plans. Therefore, in context to the identified gap, the present study will examine the challenges experienced by the project engineering managers while achieving sustainability in the UK construction industry.

According to Yu et al. [4], sustainable project management is based on the practices that contribute to the controlling of the projects and ensures the achievement of their goals relates to sustainability and as such, the region becomes one for probable practical implementation of sustainability. The study recognized that sustainable project management has an increased focus on the planning, and monitoring as well as controlling of project delivery and support processes that ensure updating and readiness of the project for overcoming problems related to sustainability, based on the environmental, economic and social principles associated with the life-cycle of resources, and processes, as well as deliverables and effects of the project.

According to Díaz-López et al. [5], the construction industry is identified as a contributor to changes in climate and depletion of natural resources. It was also recognised to have significant impact on the environment, the economy, public health, and the well-being of the cities. The authors also explained that "sustainable building is promoted as a guiding paradigm for development in the construction sector. In 1987, the Bruntland Commission initially discussed the concept of sustainable development as the development that meets the needs of the present without compromising the ability of future generations to meet their own needs” [1]. The increased public awareness of the importance of sustainable development has contributed to the mitigation of some of the negative impacts of construction on the built environment, which have been taken more seriously in the recent decades [6]. Additionally, people and policymakers as well as the building professionals have also shown increased interest in making more sustainable buildings [5]. A variety of previous studies have suggested new sustainable construction methods; but the industry has been slow in the adoption of sustainability in construction for various reasons [6]. Moreover, limited research has been previously conducted for the investigation of the barriers to more sustainable construction.

The construction industry has strong direct and indirect interconnections with the many components of sustainable development: economic, social, and environmental, which makes it an important sector to consider in achieving sustainable development. Because the construction industry consumes a high quantity of resources, enhancing its quality may have a substantial impact on society's overall sustainability [4]. Green buildings, for example, use 36% less energy than conventional structures, resulting in a significant reduction in CO_2 emissions [7]. Increasing the well-being and productivity of city dwellers can have a significant impact on the long-term health and well-being of the entire community [8]. Living in green architecture reduces cold, influenza, and asthma symptoms by 40–60%, according to a study by [9].

Sustainable construction which is about incorporating sustainability principles with traditional construction processes, has been on the rise since the latter part of the 1980s. As a result, the building sector has undergone considerable transformation over the previous decade. In this context, phrases like "exceptional productivity," "green," and "sustainable construction" are used interchangeably [10]. However, according to Barbosa et al. [2], sustainable construction most thoroughly focuses on a building's impact on its environment, as well as on its social and economic impact on its surrounding area.

According to Antwi-Afari et al. [7], technical challenges are given considerable attention in the development of ecological sustainability in the UK. They include characteristics of the systems that can assist in accomplishing green goals, such as energy efficiency and employing ecologically acceptable materials. Tools like site management and waste and material management are included in the term "project engineering management." According to Chan et al. [11], the project methodology as well as non-technical concerns currently not being sufficiently emphasized. It could be useful to evaluate the elements and focuses of the various grading systems which stipulates excellent practices and steps to attain green aims [12]. According to Owusu-Manu et al. [13], LEED, "BCA Green Mark," and "Green Globs" are the three most often used grading systems for project management assessments.

A project management package recommended by Hwang et al. [14] is also recommended in order to accomplish the desired outcomes of green building. Clearly, the goal of this project management tool is to help project engineering managers do their jobs more successfully.

Sustainable construction may be achieved with the help of these package's project management approach to achieve:

(1) Delivery of important objectives to all stakeholders involved in the project without ignoring the sustainability concept at critical junctures in the process;
(2) Green construction management practices during the construction phase;
(3) Continuous improvement through feedback and documentation of the project's life cycle.

A major problem for the construction industry, especially in the area of environmentally friendly development, is to create and implement new inventive ways to purchase, design, construct, utilize, and maintain development [15]. Customers, businesses, and society demand more stringent orders in a timely manner, cost, quality, and environmental effect, and these new methods should be able to fulfill them [16-18]. As a result, sustainable building as a key driver for these transformations must address certain critical issues: (1) Improving the construction stage's efficiency and effectiveness through better coordination across critical phases. (2) Creating high-quality products in a safe and healthy workplace while minimizing the impact on the surrounding environment and population. (3) Improving the construction industry holistically and long-term to meet changing customer, industry, and public needs. The challenges of the sustainable construction process are not due to a lack of available knowledge, technology, or evaluation methodologies; rather, they are a result of the complexity of the process itself. As Owusu-Manu et al. [13] explained, the sustainable building process has the problem of adopting new procedures and working methods for using new technologies. Changes in procedures, consideration of risks and unanticipated costs are necessary for new technology. These challenges may not be unique to sustainable construction, but the long-term goals of sustainable buildings make it difficult to quantify the advantages of addressing them.

This study aims to address the identified gaps as it is a necessity for the development of interventions and strategies to ensure sustainability in the construction industry by overcoming the challenges experienced by project engineering managers.

2. MATERIALS AND METHODOLOGY

2.1 Data Collection Procedure

The current study is based on primary findings thus the researcher conducted interviews for data collection, The data was gathered from the engineering managers of the construction industry to determine the managers' responses towards the attainment of sustainability in the industry and to understand the different challenges which had influenced the engineering managers in achieving sustainability in the UK construction industry. To gather quantitative data, a survey was conducted in order to determine how representative each person's opinions and experiences are.

2.2 Research Approach

According to Sekaran and Bougie [19], the methodological approach in a research preserves the study's validity and integrity to provide effective and reliable research. In order to verify the present study's validity, the author used the technique of inductive approach in this study. In addition, the inductive technique has been considered to achieve observations about the challenges and their impact on construction industry engineering managers concerning the attainment of sustainability. Moreover, the current study has a great deal of information regarding manager's personal experiences, which has been examined in order to provide an even efficient analysis.

2.3 Sample Size and Sampling Strategy

The study conducted by Sharma [20], sampling technique is referred to as the recognition of specific procedures that lead to the selection of sample items. Moreover, the term "sampling strategy" refers to the strategies, tools, and procedures used to pick a group of participants from the population based on the research's estimated sample size for data collection [21]. For the goal of gathering data, snowball sampling was used in the current study. The chosen respondents of the present research were project engineering managers working in the construction industry in the region of the United Kingdom. For this study, the researcher conducted semi-structured interviews. The sample size for this study was chosen to be 6-8 managers from the construction industry in the United Kingdom. It was ensured that the mangers working had approximately 3 years of experience so that the outcomes of the research were enriched with their experiences. To gather quantitative data, snowball sampling was used and a survey was conducted from 50 engineering managers. A total of 65 survey questionnaires were distributed; however, only a total of 50 responses were obtained. For the characterized impact analysis of the grouped challenges, a total of 100 questionnaires were distributed to capture the ideal responses of engineering project managers from a wider point of view.

2.4 Data Analysis Techniques

2.4.1 Sample evaluation using Analytical Hierarchical Process (AHP)

According to [22], the AHP method of analysis involves a methodological approach to achieving a decision regarding a given problem. AHP is a mathematical technique used for multi-criteria decision-making. This method of analysis consists of various steps which include:

i. Identification of the problem.
ii. Formation of alternatives.
iii. Expert elicitation.

In the last step of the AHP analysis, data of the challenges of Engineering Project Managers were presented to experts who carried out pair-wise comparisons of the costs with respect to their various classes. The outcome of the comparison was a matrix that ranked the costs in the order of highest to lowest. The experts were required to rank each identified challenge against another using the Saaty scale 1-9 [22]. Table.1 shows the Saaty scale and explanations of various attributes. For example, if two attributes are judged to have the same level of impact, the pair-wise comparison will be 1 and so on. A score of 9 is given if one attribute is assumed to be extremely higher than the other. Intermediate judgments of 2, 4, 6 and 8 are selected when a conclusion cannot be reached from the scores of 1, 3, 5 and 7 as defined in Table 2.

2.4.2 Validation of study

The AHP is usually validated using mathematical methods that would check consistency in the data obtained. The following parameters are used to obtain good consistency of data.

2.4.2.1 Consistency index

Consistency Index (CI) is then calculated using Equation (1).

$$CI = \frac{\lambda_{max} - n}{n - 1} \tag{1}$$

where, n is the order of the decision matrix and is obtained from Equation (1).

The weight vector,$\vec{w}$ is given in Equation (2).

$$\vec{w} = \begin{bmatrix} w_1 \\ w_2 \\ w_n \end{bmatrix} \tag{2}$$

Obtained from a decision matrix, Equation (3) is given as

$$A = \begin{bmatrix} a_{11} & a_{12} & a_{1n} \\ a_{21} & a_{22} & a_{2n} \\ a_{31} & a_{32} & a_{3n} \end{bmatrix} \tag{3}$$

The consistency of the decision matrix is then calculated as follows:

Multiply matrix A by the weight vector $\vec{w}$ to give vector, $\vec{B}$ in Equation (4).

$$\vec{B} = \vec{A}.\vec{w} = \begin{bmatrix} b_1 \\ b_2 \\ b_n \end{bmatrix} \tag{4}$$

where,

$$\begin{aligned} b_1 &= a_{11}w_1 + \quad a_{12}w_2 + \quad a_{1n}w_n \\ b_2 &= a_{21}w_1 + \quad a_{22}w_2 + \quad a_{2n}w_n \\ b_3 &= a_{31}w_1 + \quad a_{32}w_2 + \quad a_{3n}w_n \end{aligned} \tag{5}$$

Divide each element of vector, $\vec{B}$ with the corresponding element in the weight vector $\vec{w}$ to give a new vector, $\vec{c}$ given in Equation (6).

$$\vec{c} = \begin{bmatrix} b_1/w_1 \\ b_2/w_2 \\ b_n/w_n \end{bmatrix} = \begin{bmatrix} c_1 \\ c_2 \\ c_n \end{bmatrix} \tag{6}$$

λ_{max} is the average of the elements of vector $\vec{c}$ and is given in Equation (7).

$$\lambda_{max} = \frac{1}{n}\sum_{i=1}^{n} c_i \tag{7}$$

Table 1. Saaty scale of decision preference (Saaty, 2003)

Judgment	Explanation	Score
Equally	Two attributes contribute equally to the objective	1
Moderately	Slightly favour one attribute over another	3
Strongly	Strongly favour one attribute over another	5
Very strongly	Strongly favour one attribute with demonstrated importance over another	7
Extremely	Evidence favouring one attribute over another is of the highest possible order of affirmation	9
Intermediate Judgment	The intermediate values are used when compromise is needed	2,4, 6,8

Source: [23]

Table 2. Random index table

n	3	4	5	6	7	8	9	>9
RI	0.58	0.9	1.12	1.24	1.32	1.41	1.45	1.49

2.4.2.2 Consistency ratio

The consistency ratio is the most significant index to validate data acquired. This value greater than 0.1 (CR>0.1) indicates inconsistency in the acquired data while consistency less than 0.1 (CR<0.1) implies consistency in the data acquired at confidence in the decision obtained.

Consistency Ratio is given in Equation (8).

$$CR = \frac{CI}{RI} \qquad (8)$$

Where RI is the random index and its value is obtained from Table 2.

3. RESULTS AND DISCUSSION

3.1 Ranking the Identified Factors based on their Impact level on Inhibiting Sustainability Achievement in the UK Construction Industry

The Analytical Hierarchical Process which was introduced by Thomas Saaty in 2003 is an effective analytical tool that deals with complex decision making and helps the decision maker to make the best decision. This process deals with complex decision making by reducing the complex decision to a series of pair-wise comparisons and brings out results. The tool uses a technique for checking the consistency of the decision maker’s evaluations which helps in reducing the bias in the decision making process. The AHP analysis of the results from data obtained was carried out through a series of steps which are discussed below.

3.1.1 Hazard data validation and consistency check

Hazard data validation and consistency check is done to ensure that the decision arrived at in this research is consistent and coherent. The hazard factors are grouped into five (5); Establishing a Climate of Trust (ECT), Providing Support within the Team (PSWT), Taking Responsibility and Ownership (TRO), Providing a Suitable Context for Development Work (PSCDW), General Project Management (GPM) as presented in Table 3.

3.2 Identification and Evaluation of Challenge Factors

The AHP analysis carried out in the study ranked the costs and classified them according to their prevalence in the generation of construction and demolition wastes in the construction industry.

The responses obtained from the questionnaire issued to the 100 sampled project managers and Engineers, captured the following impact factors as possible members that contribute immensely to the challenges of Project Engineering Management (PEM).

Chart results showed that the major cause of concern in handling challenges to Project Engineering Management are the GPM and ECT which is ranked class 1 and the PSCDW which is ranked class 2. TRO and PSWT ranked a similar class of 4, which indicate that with minimal consideration in Project Engineering Management, these two factors do not pose a tangible threat to proper management of engineering projects. Pictorial review is as shown in Fig. 1.

Table 3. Project engineering management challenge factors, percentage of occurrence and level of impact

PEM Challenge Factors	Percentage of occurrence	Level of Impact
GPM	59.28	40.2 High
PSCDW	43.51	43.67 Low
TRO	36.78	53 Low
PSWT	40.22	45.75 Low
ECT	51.29	36.67 Medium

"A total of 19 managerial activities and challenges were identified in the questionnaire and interview. These activities and challenges fell into five main classes: general project management, providing suitable context for development work, responsibility and ownership, providing support within a team, and establishing a climate of trust, which were defined as either task or people-oriented based on existing literature" [24].

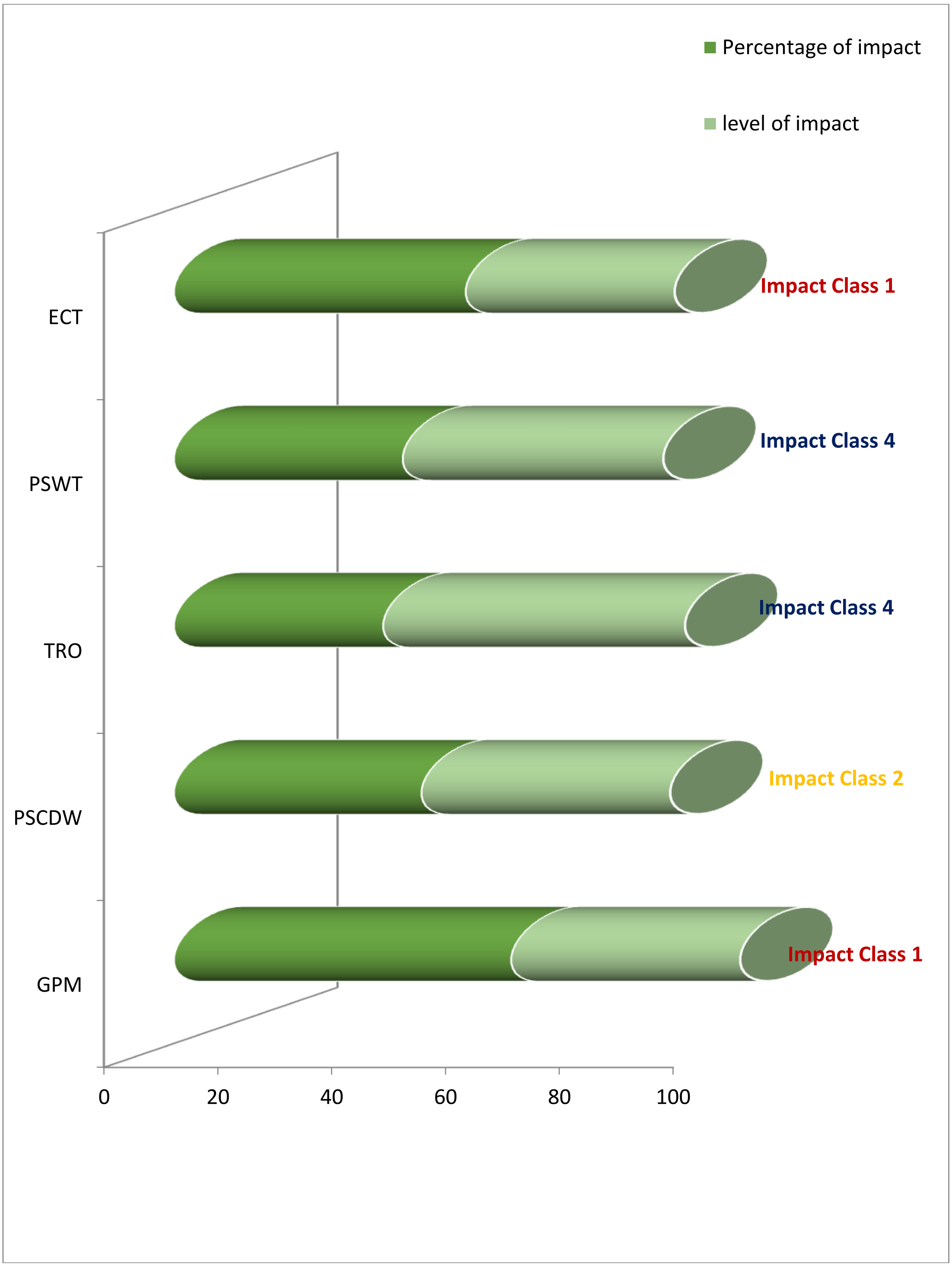

Fig. 1. Bar chart relationship of various challenge factors with respect to level of impact and percentage of occurrence in PEM

3.3 General Project Management

"This class involved activities and concerns related to organizing work, keeping the project under control, and ensuring the progress of work and was the most numerous class of the three task-oriented classes. It consisted of five subcategories: clarifying roles and setting goals, coordinating the whole, time management, monitoring work and documentation, and acting as an interface" [25].

"The largest category, clarifying roles and setting goals, contained activities such as defining team member roles, forming and delegating tasks, and deadlines resulted to 89.89% of occurrence at a 58% level of impact. The managers reported that finding roles for every team member was challenging, especially for the less active team members. Furthermore, in some of the cases defining separate roles for all members when there were many representatives from the same discipline was reported as difficult" [26].

All of the managers emphasized the importance of coordinating the whole, which includes activities like defining the whole, maintaining project (direction) control, seeing the big picture, and coordinating the work of various parties. Activities like sharing information between subgroups and ensuring everyone was heading in the same direction were deemed important, and the activities were the second most popular activity category overall. This contributed 25.28% of occurrence at a 38% level of impact.

Time management, involved scheduling the project and meetings of the team, and clarifying how much each member had time to use for the project contributed 51% of occurrence at a 45% level of impact. One of the most frequently expressed challenges was creating schedules so that all team members could participate in the team meetings or informal gatherings, a challenge reported by all project managers.

The category of documentation and monitoring work resulted to 71.74% of occurrence at a 47% level of impact, included segments reflecting documenting decisions and following up on delegated tasks, for example by checking the situation in weekly team meetings or inquiring on progress by phone or email.

The final subcategory of the general project management activities, acting as an interface, was broken down into a few sections that discussed acting as a liaison between the team and external parties, like the project sponsor, and being in charge of responding to their questions. This contributed 58.97% of occurrence at a 50% level of impact.

3.4 Providing a Suitable Context for Development Work

The class consisted of innovation project specific activities and concerns aiming to boost the working of a multidisciplinary team. The three categories of the class were: establishing ways of working, accommodating to diversity, and encouraging exploration.

The category of accommodating to diversity was the largest category of the class with about 40.23% of occurrence at a 36% level of impact. The category included interview segments reflecting how diversity affected the ways of working and the behavior of the manager. For example, creating a common vision and understanding was more challenging due to the educational and cultural diversity of the team, and ideation challenges resulted from the different perspectives and approaches of designers and engineers.

Encouraging exploration, in turn, was by far the most common activity reported in relation to creating a suitable context for the project resulting in 64.05% of occurrence at a 46% level of impact. It contained activities such as explicitly requesting the team members to produce several solution alternatives to problems, encouraging team members to take on multiple perspectives, and avoiding providing any ready solutions.

Finally, the third category, establishing suitable ways of working, included concerns such as "selling" ideas to the team, protecting ideas from premature criticism, and communicating the desired behavior to the team contributed 25.58% of occurrence at a 62% level of impact.

3.5 Taking Responsibility and Ownership

"The final task-related class contained interview segments reflecting the extent to which the managers distributed decision making power (in the categories of dispersed decision making and providing autonomy) and personally took part in the development work (in the category of hands-on participation). The class consisted of the following categories: providing autonomy, decisions made solely by the manager, dispersed decision making, and hands-on participation" [27].

The managers reported much more distributed decisions, with dispersed decision making and providing autonomy being more numerous than hands-on participation or decisions made solely by the manager with a 62.11% of occurrence at a 40% level of impact. Autonomy was mainly provided through offering more general level task definitions rather than specific instructions, and all the managers provided decision authority to the sub-groups of the project on their own tasks.

In contrast, in the category of hands-on participation, the managers described taking part in the actual development work of the project, typically in building the prototype—more precisely, this involved activities related to concept creation and ideation generating 30.44% of occurrence at a 57% level of impact.

Finally, the category of decisions made solely by the manager with 29% of occurrence at a 78% level of impact, reflected the project manager having a strong role in decision making and making the final decisions in situations where no clear decisions could be made with the team. Typically, however, the project managers reported making decisions alone only in minor decisions and events such as deciding on meeting times.

3.6 Providing Support within the Team

Providing support within the team was the larger of the two classes of people-related managerial concerns reported by the project managers. The class included managers' actions aimed at gaining the participation of all project members, showing appreciation, and taking individual needs and differences into account. It consisted of four categories; encouraging team member participation, being available and present, showing concern and appreciation, and providing positive feedback and recognition.

"Encouraging team member participation was the largest category in the class in terms of both the activities as well as the challenges. The methods of encouraging participation included actively asking for opinions, explicitly encouraging participation in tasks, dividing the team into smaller subgroups and contacting quieter team members individually to prompt for their view. The amount of challenges in the category was also the second largest, surpassed by only difficulties in accommodating to diversity" [2].

Some project managers emphasized the importance of being available and present for team members by scheduling one-on-one meetings, maintaining phone contact, and being present while subgroups worked on their own tasks. Showing concern and appreciation, in turn, required managers to be concerned about the well-being of individuals and to value the expertise of each team member. Positive feedback and recognition primarily consisted of positive feedback from well-done work. No manager reported providing negative feedback, and no problems were reported in any of these three categories.

3.7 Establishing a Climate of Trust

The final class, establishing a climate of trust, included managerial concerns of fostering open interaction and good team spirit by aiming to act as role models and emphasizing the importance of learning rather than succeeding. The class consisted of three categories: creating an open and trustful atmosphere, solving interpersonal issues and acting as a mediator, and minimizing fear of failure in the project team.

"The largest category, creating an open and trustful atmosphere, was highlighted by all managers. Managers emphasized the importance of getting to know their team and making the team meetings more relaxed. They encouraged team members to give feedback, act openly and relax themselves, and aim not to dominate the meetings. The challenges occurred with team members being reluctant to spend time and participate actively in team meetings or informal gatherings" [28].

Managers engaged in one-on-one discussions with team members and mediated disagreements among team members as part of their activities in the category of solving interpersonal issues and acting as a mediator. The most common challenges were caused by the project manager's and some team members' clashing personalities. Finally, some managers made an effort to lessen the fear of failure by stressing the value of learning rather than immediate success. This category contained no challenges.

4. CONCLUSION

The primary aim of the present study was to identify the challenges experienced by the project engineering managers while achieving sustainability in the UK construction industry. The study has proven to be beneficial to employers in the construction industry as well as the government and policymakers by pin pointing the challenges related to sustainability in the construction industry, hence providing appropriate and suitable recommendations towards overcoming such challenges.

The study was also able to identify the factors involved in the challenges of the project engineering managers towards achieving sustainability in the UK construction industry. The results of this study show that there are several difficulties faced by project engineering management teams when implementing sustainable construction practices. The study has highlighted that lack of knowledge about sustainable technologies is among the biggest issues. The findings reveal that project engineering managers do not appear to grasp enough about environmentally friendly building practices and materials. The study has also stressed the notion that it is the duty of the engineering management team to ensure that the overall output does not deviate from the performance standards. Moreover, it has been evaluated that lack of acquaintance with sustainable technology has a detrimental impact on the overall project outcome and performance. The findings have also highlighted that the lack of expertise in the sustainable supply chain, recyclable materials, and sustainable design requirements presents a challenge to project engineering management teams in the field of sustainable construction. They are compelled to speak with these types of professionals on a regular basis. Lack of time to implement sustainable building practices on construction sites due to the numerous contract types used for project delivery has been cited as another difficulty. Moreover, it is also evaluated that conflicts of interest and poor communication amongst project engineering co-workers are additional difficulties.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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