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The Engineering Management Skills and Competencies Development Framework

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Abstract:
Background*: This paper presents the development and validation of an Engineering Management Skills and Competences Development Framework (EMSC-DF) and its supporting guidelines.*
Materials and Methods*: The research employed a mixed-methods approach to address the critical need for development of engineering managers. A comprehensive literature review established the theoretical foundation. Subsequently, 30 semi-structured interviews were conducted with industry professionals to gather empirical data on essential skills and competencies. Content analysis of the interview transcripts led to the drafting of the EMSC-DF, which was then returned to the interviewees for them to validate.*
Results*: A developed and validated Engineering Management Skills and Competencies Development Framework and Guidelines.*
Conclusion: *The resulting framework provides a practical tool for organizations and individuals to enhance engineering management capabilities.*
Key Word*: Engineering; Education; Skills; Competencies; Nigeria.*

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I. Introduction

Training has been identified as the main EMSC development and improvement approach in the Nigerian Society of Engineers (NSE) (Onyia and Nwoji, 2020). However, Rwelamila (2007) stated that there are strong indications to suggest that higher learning institutions are unaware of what is required to produce an efficient manager for 21st century engineering projects. In terms of improving engineering management education, Need (2007), avowed that a review of literature regarding the suitability of engineering management education reveals an urgent need for more "soft skills" such as personnel skills, stronger leadership, better communication and greater understanding of main business principles.

Over thirty years ago, Alpander (1986) after studying the responding Fortune 500 companies in the United States, revealed that organizations adopt more of a traditional approach when training their managers in areas like motivation, communication, evaluating and building supervisors' influence. The other managerial responsibilities, like planning, organising, team building, and production control, use a more collaborative/participative philosophy at work. This revelation has been validated by some recent study (Carvalho and Rabechini Junior, 2015; Ebrahimi-Mehrabani, and Azmi-Mohamad, 2015). Banihashemi *et al.* (2017) and Noe *et al.* (2017) affirmed that engineering managers and supervisors must learn other skills apart from the traditional technical skills relevant to their jobs. The study further emphasised the need for managers and supervisors to also develop skills that are more conceptual and interactive (Ogbenjuwa *et al.* 2018). Such skills are likely to lead to a more collaborative management philosophy. These skills are likely hard to develop as Carvalho and Rabechini (2015) warned, since they are behaviourally non-specific and are not readily learned through repetition.

When developing EMSC, the project managers must become interactive and see every aspect of the development from a social and human perspective (Kerzner and Kerzner, 2017). They must develop techniques and tools which stimulate subordinate assistance and involvement. Conceptual EMSC on the other hand involves extensive and/or education experience that develops over time and this study developed the technique for building capacities of engineering managers.

1.1 Engineering Management Skills and Competences (EMSC)

As the manager and/or supervisor is the one at the bottom of the project management pyramid, who oversees the materials, labour and processes used to develop an engineering project (Hotek, 2000), it is vital to identify the essential EMSC required for their job. Traditionally, supervisors or managers accomplish work and targets through other people (Almatrooshi *et al.* 2016). They usually practice their managerial and supervisory

skills by controlling and directing the way in which other personnel do their work (Hardison *et al.* 2014). Skills required to successfully manage projects are constantly changing (Bumblauskas *et al.* 2018). Twenty years ago, project success was about time, budget and quality. But currently, projects are expected to meet its business objectives to be successful (Verzuh, 2015). EMSC are used in managing production operations (Heizer, 2016), but the manager and supervisor skills and competencies have changed from that of controlling and directing how, where and when work is accomplished to successfully leading and effectively helping employees control all aspects of their own work (Sallis, 2014).

A fundamental skill for a manager or supervisor is to be familiar with the latest developments in his or her field of operation as well as the operating technology, and be prepared to deal with the continual and rapid changes associated with it (Ika and Hodgson, 2014). To achieve this, the supervisor must understand technology as an improving concept. A supervisor or manager must possess skills and competencies that will enable him or her to bring out the best from both technology and employees (Omotayo, 2015). In all, the modern manager must be a technically oriented team coach (Wallo et al. 2013). Supervision and management are in fact formative (Range *et al.* 2011) as the goal is to foster both professional development and growth. Certain managerial and supervisory practices required are to encourage worker's self-esteem, effectiveness and efficiency as this constitutes the primary goal of the manager and supervisor skills (Kalule and Bouchamma, 2013). Effective managerial skills and competencies are among the most important tools for improving the quality of organisations (De-Grauwe, 2007).

EMSC is best explained through the comprehensive definitions of competence. Researchers have defined competence as having qualification, but competence is distinguished from qualification, characteristics and others in that it can only be understood by the field workers in a professional environment (Hersey and Laws, 2009). It is characteristics to excel and or occupational knowledge and skills (Sandberg 2000), a validated operational knowhow (Li and Hu, 2022), which is composed of technical and managerial knowledge in a personal dimension (Blanka et al. 2022), the complex capacity to act, which requires support from the mobilisation and the effective combination of various internal and external resources inside categorised situations (Kislov et al. 2014). Set of behavioural patterns that an incumbent is required to bring to his/her position in order to perform the tasks and functions with competence (Srikanth and Jomon, 2020). For Hunnius and Schuppan (2013), the concept of competence considers what a person can do in a working environment, regardless of how this knowledge and capability was acquired. Competence is a combination and application of skills, knowledge and other qualifications and characteristics to satisfactorily perform a given task (Hwang and Ng 2013). Competence is beyond a qualification instead, it focuses on successful accomplishments. Competence is dynamic and socially constructed (Moreau and Mertens, 2013).

To successfully perform a job, specific skills, knowledge and behaviours are required (Coleman and Bourne, 2018). Thus, competencies, is simply the demonstrable characteristics of an individual, including skills, knowledge and behaviours, that enable successful performance (Munene et al., 2018), or as the proper combination of technical know-how, knowledge and behaviour well-structured according to the goal and the objectives in certain working situations (Wafae and Abderazzak, 2024). In fact, these meanings are aligned with the European Credit System for Vocational Education and Training ECVET, which states that competence is the proven ability to apply skills, knowledge and personal, social or methodological abilities in work or academic environment and in a personal and professional development (Ryan et al. 2018).

1.2 Engineering Management Skills and Competences (EMSC) Development

The concept of managerial skills and competencies development has been around for centuries. First of all, The Alpander (1986)'s study revealed that any organization wishing to have collaborative style of management, must first support and incorporate more interactive and conceptual skills in the company's managerial training programmes for first line management. The improvement of engineering performance in Nigeria rests on the shoulders of managers and supervisors (Ogbenjuwa *et al.* 2018). Remember it is the responsibility of first line managers and supervisors to interpret both corporate and project goals and to motivate the workers to achieve them (Sears *et al.* 2015). And of course, this requires strong managerial skills (Alpander, 1984). Human beings are viewed as beings capable of developing and improving their professional actions (Rahim, 2017) thus enabling them to perform better in their projects (Bushuyev and Wagner, 2014).

As stated by Too and Weaver (2014), the primary obligation of engineering managers is to achieve the outputs and deliverables as efficiently as possible. This is only achievable through requisite EMSC. Since managerial and supervisory skills are known to be soft skills, which have more to do with behavioural attitude and personal learning, it requires coaching and mentoring to achieve the best results (North and Kumta, 2018). Furthermore, personal learning promotes competence in approaching work-related problems (Borkovskaya *et al.* 2018; Dave *et al.* 2016). Site managers who have developed personal learning habits will possibly do better in their work because they have and continue to develop more EMSC (Naveed *et al.* 2017). In addition, managers

who have developed communication and problem-solving skills feel more confident and competent (Lankau and Scandura, 2002).

The EMSC developed through personal learning directly relates to the job performance of the individual and consequently on their business performance (Young and Conboy, 2013). It is very important to note that personal learning produces a change in attitude and, most importantly, shapes how individuals respond to tasks, challenges and work environments. Interestingly, employees, who experience personal learning tend to have more positive reactions to their work because they have developed greater confidence and skills. Personal learning should thus be related to attitudes for developing EMSC (Azeiteiro *et al.* 2015). And that managers who have developed communication and problem-solving skills feel more competent and demand actual feedback for the value of their contributions. Taking into consideration all available literature (Patterson *et al.* 2017; Wilson et al. 2016; Crawford, 2005), it is proposed that personal learning mediates the relationship between supervisory and managerial skills development and supervisor's work outcomes in terms of job performance and career satisfaction. International Project Management Association (IPMA) main idea is to develop the competencies of managers through training, mentoring and coaching and thus enable them to perform better in their projects (Bushuyev and Wagner, 2014).

1.3. Areas of Development and Development Profile

In developing or improving EMSC, an organisation should know what it needs to empower through measurement and evaluation of its EMSC profile (Phillips and Phillips, 2016). Otherwise employees must know what EMSC profiles are defined and required for the various tasks within the firm and must be able to perform analysis that will enable them to choose the right development or improvement plan. The managers must know where to go for the development of the identified and required EMSC (Pyzdek and Keller, 2014). Therefore, generic and flexible profiles should be created, which provide 80 per cent facts. These development profiles provide the organisation with a detailed framework of EMSC descriptions required to support its core project business and they also provide the employees with a comprehensive overview of the desired competences and the skill-sets to acquire his/her personal career development (Phillips and Phillips, 2016).

Bushuyev and Wagner's (2014) work was guided by two concerns: first, that high quality skills are essential for achieving performance improvements, but these are in short supply; and, second, that few firms develop effective human resource strategies to meet skill needs in a changing project environment. Development of engineering management during the last 20 years has been broadly beneficial in terms of industrial performance, however, there is the need for continuous improvements in personal development and learning of managers (Wilson et al. 2016). The development of managers may be unsustainable in the long term without substantial changes to training to address the challenges, and the provision of emerging and future skill needs. Davis (2014) reviewed the different areas over time, and the project has been looked at for the determination of its success. The 1970s examined the technical aspect of a project, the 1980s looked at how projects related to the client organisation. The 1990s developed CSF and recognition of stakeholders. The 21st century is more stakeholder-focused, examining the project life cycle goals. In a further study, Davis (2016) outlined three dimensions to determine project success: benefit to stakeholders, client specific issues and the well-known time/cost/quality measurement. Evidence from available literature (Banihashemi *et al.* 2017), suggested that the collective agreement of stakeholders, which includes the project team and the environment, and the client organisation regarding the degree to which the project meets its agreed objectives and goals, is what truly determines project success. Though Davis (2017) shared a similar view, he went on to warn that to stakeholders, the value of these dimensions is not of equal importance; as such, relevant dimensions vary according to the stakeholder groups. To attend this collective stakeholder's satisfaction requires EMSC-DF.

1.4. Design of the Engineering Management Skills and Competences Development Framework (EMSC-DF)

The EMSC defines the categories of personal and performance competence. This is intended to ensure individuals, their organisation, and professional bodies apply an appropriate methodology for the assessment, recognition and development of EMSC among individual managers and supervisors. The EMSC-DF is designed to; be clear, understandable, and straightforward to use, cover the range of EMSC a manager requires for successful performance, be used by all managers regardless of the size, nature, type, or complexity of projects. Being generic, it is necessary to ensure that the EMSC-DF is transferable and applicable across industry (Cartwright and Yinger, 2007).

The EMSC-DF are designed for, but is not limited to the project managers, site managers, all members of a construction or engineering management office, senior management, human Resource personnel, organizations and teams, educators teaching construction management and other related subjects, trainers developing management tutorial programs, project and program management industry consultants. The EMSC-DF structure represents a typical competence standard. It identifies the following: Elements of EMSC. These consist of several elements, which reflect the activities in which managers are expected to be experienced;

Performance Criteria: Each element is described by performance criteria, which stipulate the outcomes to be achieved to demonstrate competent performance; There are different types of evidence associated with each of the performance criteria. This forms the basis upon which EMSC can be self-assessed.

1.5. Tailoring the Engineering Management Skills and Competences Development Framework (EMSC-DF)

Organisations must use their own discretion, in accordance with their culture, when customizing the relevant elements of the EMSC-DF to apply to their business approach. In other words, the EMSC-DF should be tailored by the organisation to represent their view of strategy on construction management. An organisation may choose to tailor the EMSC-DF to not only select the EMSC relevant to their organisation, they may also choose to identify and specify the relative importance of each skill or competence and the required level of mastery of each of them to their operations.

Cautiously, organisations must note that the EMSC-DF is based on managers and supervisors being competent to manage most projects, most of the time. This is because the more an organisation deviates from this EMSC-DF, by scaling back its models and guidelines, by diminishing the relative importance of several criteria contained in the EMSC-DF, or deselecting elements and the respective performance criteria, the more the organisation risks the managers' competencies to perform in other project environments and organisation (Cartwright and Yinger, 2007). To maximize transportability between project environments and organisations, it is strongly encouraged to apply as much as is feasible of the EMSC-DF and guidelines exactly.

1.6. The Framework

The process of development, validation and arriving at the final framework involved the following stages as presented by Cartwright and Yinger (2007);

a. A thorough review of literature to identify key aspects of the framework was conducted. Understanding of the meaning of EMSC was established, and the significance of EMSC was evaluated. Development and improvement of EMSC and development strategies and approaches in the literature were discussed. Also, the review of literature established challenges of EMSC development.

b. The views of professionals were elicited to contextualise the framework components; all the gaps identified between the literature and the NSE were addressed with a focus to the currency and relevance of practice and ethics of the NSE.

c. The draft framework was developed and validated by eliciting the views of potential beneficiaries and professionals in the NSE.

d. Improve the framework after taking on board the views of professionals and beneficiaries through validation of the framework.

1.6.1 Duration of Training

The duration of the training would largely be subject to EMSC's desired. Onyia (2019)'s research identified a series of EMSC and they are categorised into 5, 10, 15, 20 most important EMSC. The study showed that the top 20 most important EMSC need development and improvement and are not difficult to develop. Organisations and trainers should profile the trainees, to identify and understand the needs of trainees and skills gaps. The training sessions should be as concise as possible, and there should be a 15 or 30-minute refreshing break for every one or two hours of training sessions respectively.

1.6.2. Admission Requirement

The only entry requirement is membership of Nigerian Society of Engineers (NSE) or certification from COREN. At managerial and supervisory level, affiliation with a professional body like NSE and COREN is necessary because of the stringent membership requirements like basic education, professional experience and code of ethics they demand of their members. This is the best level for entry into this training. Students of engineering related programmes who hope to manage or supervise projects and other potential trainees should be urged to join a professional organisation like NSE as membership is necessary for admittance into training for EMSC required in managing construction projects. Fresh graduates who intend to pursue a career in engineering management should be attached to work under an experienced manager and his/her supervision for the five years' mandatory experience building period required for election as a member of NSE or similar construction organisations.

1.6.3. Education, Training and Practice Stage

2.6.3.1. Education

According to Fryer (2004), education builds the ability and capacity of one to think and judge objectively; consequently, potential trainees should have acquired the basics for productive SC development and improvement training (Naveen & Babu, 2015). This was supported by Syben (2008) and ITSJ's (2014) observation that education simplifies and enables a well-informed and knowledgeable approach and strategy to practical problems, it also provides a rudimentary platform for EMSC development. With the general education acquired, SC focused education is required in skills training to guarantee that the needs and peculiarities of the engineering sector are

taken into consideration. Less emphasis should be given to general courses like Mathematics, Physics and Chemistry while more emphasis should be given to EMSC that covers materials, principles, enterprises, and other EMSC (Faherty, 2015). The education should involve social networking, psychological confidence boosting, reporting, and basic communication. This is needed for profiling and identification of EMSC gap in an individual.

2.6.3.2. Training and Practice

It is the aim and objectives of this stage to change both the attitude and behaviour of the trainee. The principal goal is to ensure that the EMSC are developed and improved efficiently and effectively. The trainer should be resourceful and up to date with recent global practice. The trainees should be involved in EMSC training design and therefore accomplish significant change in the way projects are managed by them. The training session must be practical and not just theoretical as practiced. Trainees must be shown the what and how of engineering management. The trainers must begin the training with simple demonstrations describing what to do and how it should be done (Rothwell *et al.* 2018). All questions on who does what, when, and where must be explicitly answered by the trainer. At training sessions, the trainer should take time to slowly demonstrate the EMSC in bits for the trainees to understand and learn the steps in the skills they are being taught. Every training session is to be trailed immediately with take-home assignments and industrial practice to enable the trainees to internalise the new knowledge. These practices and assignments should be done under the observation and assessment of a trainer at a convenient pace to ensure the test-task is performed correctly and the EMSC observed and scored accurately. During practice, trainees must make a conscious effort to replicate all that the trainer demonstrated. Practice should include individual and group sessions to develop and assess how the trainee applies the acquired EMSC as an individual and as a team. Training should be site and delivered in a simulated environment as close as possible to real life situations. This ensures that no aspect of the taught EMSC is left out. Before the completion of training is certified, both the trainer and trainee should ensure that the EMSC is performed repeatedly, in the most updated way, and almost effortlessly to engrave the EMSC in the mind and habit of the trainee. These should be achieved through the provision of the necessary resources and materials for further development and practice to enable the trainee to study and rehearse on their own.

1.6.4. Experience Stage

Unlike the training programme that requires the collaboration of the industry and training institutions or trainers, the experience stage only requires direct collaboration between the trainee and the industry. At this stage, the instilled training is completely focused on the engineering sector. At this stage of the training, the industrial experience becomes the trainer and the trainee is exposed to applying the acquired EMSC in management of projects, under supervision and reporting directly to an experienced manager.

The key steps to follow in ensuring that most relevant experiences are acquired by trainees are already being executed by NSE and most of the professional construction organisations through their mandatory five-years corporate experience membership requirement. But more needs to be done to maximise this 5-years' experience period. A graduate member of NSE or other professional organisations hoping to meet the requirement for an election to corporate membership status should be employed, mentored and tutored by a more experienced and qualified member.

The experiences acquired in EMSC would facilitate the eventual EMSC development training. A corporate member of NSE or certified by COREN is involved in managing any engineering project should collaborate with the trainer and continue to use the project for his/her experience.

A corporate member not involved in any on-going project would be required to find a project, engage and fully participate in it, even as an attaché, volunteer or in the worst-case scenario, as a visitor.

II. Materials and Methods

The research followed a sequential mixed-methods design, beginning with a thorough literature review to identify existing frameworks and concepts related to engineering management skills and competencies. This review informed the development of the semi-structured interview protocol. Thirty industry professionals, including project managers, engineering directors, and senior engineers from diverse sectors, were purposely selected to participate in the interviews. Each interview session lasted an average of 35 minutes. The interviews explored their perspectives on the critical skills and competencies required for effective engineering management. Transcripts of the interviews were subjected to content analysis using a thematic coding approach to identify recurring patterns and themes. These themes formed the basis for the development of the EMSC-DF and supporting guidelines. The draft framework was then presented to the interviewees for validation through a feedback session, ensuring its practical relevance and alignment with industry needs.

2.1. Development and Validation of Framework

This study has a clear aim and objectives and adopted a double semi-structured interview approach to support and boost data gathering efforts, which is most suitable for qualitative data gathering of this research. The study conducted thirty (30) in-depth semi-structured interviews on engineering professionals. The first interviews were traditionally conducted in a private and individual session; it was averagely estimated to have lasted on an average of 45 minutes per session. London South Bank University Research Ethics Committee reviewed and approved this study. LBSU research practice code and other relevant codes were strictly adhered to throughout the entire research.

The main intention of the researcher is to develop and validate a framework after analysing the data collected. The findings from the data collected from the first semi-structured interviews were used to develop the first draft framework. This draft framework was developed through the analysis of data gathered from NSE and review of relevant literature. The final state was an improvement on the first draft obtained from the opinions and inputs of the industry after the first draft was distributed for review and validation. These inputs cut across all levels of management; the researcher hopes that this effort validated the second draft of the framework. The framework was validated by giving due cognisance to the following areas;

1. The framework's comprehensive and robust
2. Logical, if people can follow it
3. Perceived to be of value and use
4. Areas of further improvement (where necessary)

This was necessary to make the framework thorough, detailed and to remove bias.

Frameworks can be validated through interviews, questionnaires and the use of focus group discussions.

The thirty (30) participants who were interviewed during the collection of data, all thirty participants indicated interest to participate in the validation exercise, were contacted for the validation process. They unanimously chose another round of interviews because it will give them abundant time to study the framework, its guidelines, and discuss their concerns and feedback efficiently. Seventy-two hours were given to them to study the framework and its guidelines as well as to respond to four questions that reflected: comprehension, robustness, acceptability, and area for improvement. The comments, observations and outcome of the semi-structured interviews for the validation exercise were incorporated in the final framework and guidelines.

This validation of the proposed framework and guidelines is for appropriateness to targeted practitioners. According to Bapir (2012), validity means truthfulness, referring to the bridge between theory and practicability. Bryman (2008) agreed with this and stated that validity is the integrity of the finding of a research study. The essence of the validation of a framework is to determine that it correctly represents the social concerns to which the research was set to address in the first place (Hammersley, 1997). Similarly, Flick (2014) and Gagliardi *et al.* (2011) stated that the validation function has been met once it is demonstrated that a proposed framework or guidelines has relevance and it has more strengths and less weaknesses than any other existing framework. All the questions were structured to address the objectives of the validation process. The explicit objectives of the validation were as follows:

I. Evaluating the suitability and significance of the components of the proposed framework and guidelines;

ii. Assessing the fundamental logic in the underlying relationships between the different components of the framework and guidelines.

Iii. Measuring the usefulness, practicality and applicability of the proposed framework and guidelines in the construction industry; and

Iv. Evaluating the strengths and weaknesses of the proposed frameworks and guidelines.

2.2. Characteristics of Participants in the Development and Validation of EMSC-DF

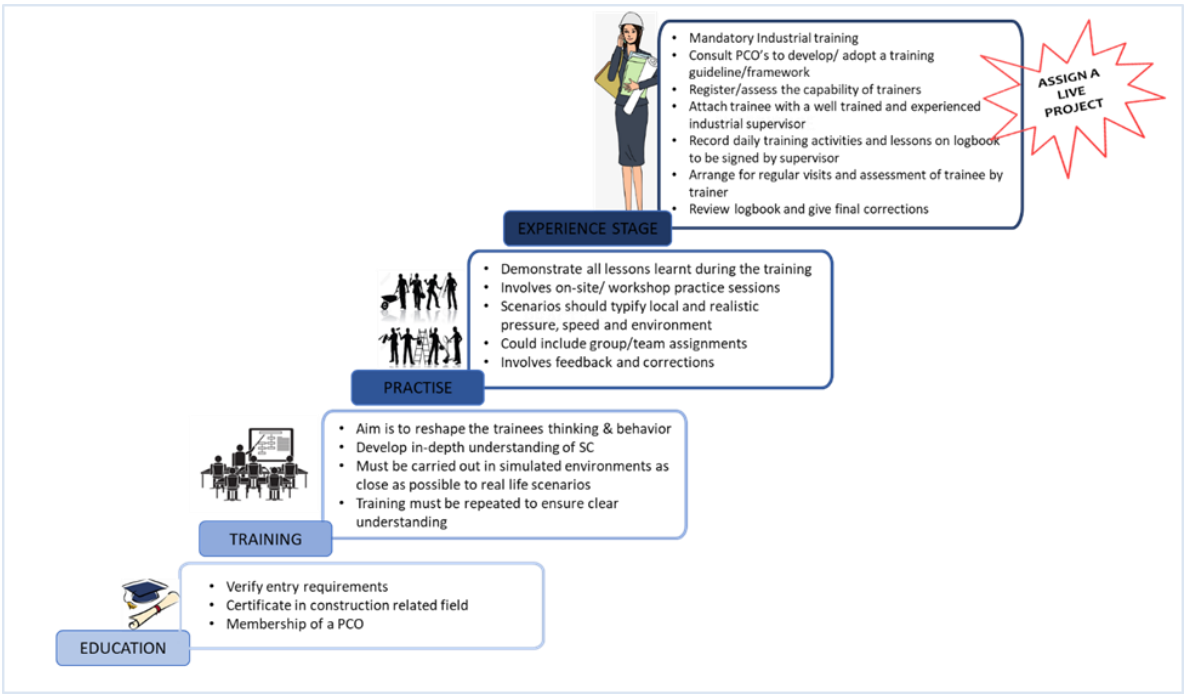
A total of thirty participants from thirty different organisations (all members of NSE) were involved in the validation survey. These were selected from the 30 participants of the first semi-structured interviews. Of the thirty (30) participants selected, nine (9) were Executive directors and CEO, twelve (12) were project managers and project engineers and the last nine (9) were site engineers, managers and supervisors. Twenty were male while ten were women. These were necessary to ensure that the inclusive views of different levels of management and genders were captured, as was the case during the main interviews. Being members of NSE meant that none of the participants had less than five-year experience; with the project managers and CEOs having an average of ten and fifteen years of construction management experiences respectively.

III. Result

STAGE 1 - EDUCATION			
Description	**Activities**	**Who is Responsible for Outcome**	
This stage emphasises the focus and importance of education. It deals with ascertaining that the education that helps in preparing the trainee for a career in engineering management is acquired. The lessons that the trainee received at the tertiary and high schools come to bear here. Trainees undergo classroom-like teaching of theories which richly cover the EMSC they are being trained for.	Identify relevant general education courses that will prepare the trainees' mind and develop their understanding of the EMSC in focus. Identify trainers with requisite knowledge and who are up to date in their EMSC proficiency to deliver the training. The industry, trainers, professional and corporate organisations like NSE should jointly develop the curriculum and expected performance outcomes and monitor the quality and outcomes of the training.	Trainers, Professional construction organisations like NSE must work together to monitor and ensure that each does what is expected of them.	The trainee must have basic knowledge in the built environment, understand, and be able to successfully apply the developed EMSC in any given work environment.
STAGE 2: TRAINING			
Description	**Activities**	**Who is Responsible for Outcome**	
This is the focus. The goal of this stage is to reshape the thinking, attitude and behaviour of the trainee from unskilled to skilled and then competent.	1. Elaborately describe the EMSC and procedure of applying it. 2. Break the procedures of application into smaller simple steps. 3. Use real-life examples to demonstrate and illustrate. 4. Repeat difficult areas as often as necessary to ensure clear understanding among trainees. 5. Give opportunities for trainees to discuss in groups to internalize the knowledge. 6. Give opportunity for comments, questions and feedbacks immediately and give corrections	Trainers or training institutions. Closely monitored by the PCO.	The trainee must be able to solve some mental case studies. The emphasis should be on the ability to adhere to correct the procedure in applying to any EMSC.
STAGE 3: PRACTICE			
Description	**Activities**	**Who is Responsible for Outcome**	
Effecting the automatic transformation of knowledge, attitude and behaviour is the aim at this stage of the training. In some cases, activities of practice can run simultaneously with those of the training.	1. Describe a task and ask the trainee to perform it with the SC taught. 2. The task must be in real life scenarios. 3. Repeat tasks with more local and realistic pressure, speed and environment. 4. Observe and obtain feedback, then make corrections where necessary.	Trainers, and Training Institutions, closely monitored by PCO.	Trainees should execute assigned tasks with limited or no coaching, just observation. Trainees should be encouraged to independently use his/her judgement to perform the task. Assessment is based on the outcome of the task performed.
STAGE 4: EXPERIENCE			

Description	Activities	Who is Responsible for Outcome	
This is an industrial stage; it provides an opportunity for the trainee to perform real-time tasks on real projects, thus learning, developing, and improving the EMSC especially those that are practical based or can only be learnt working on real project situations.	1. Assess the organisation for industrial training, 2. Enter a formal training agreement or Memorandum of Understanding with the organisation before training starts. 3. Directly introduce trainees to the organisation, then to his/her industry supervisor. 4. Ensure logbooks are used to record daily training activities and must be checked and verified by the industry supervisor. 5. Trainer must arrange regular interval visits to ensure the trainee is actively engaged in areas of training. 6. For training lasting longer than three months, arrange for trainee visits to the trainer for appraisals and further instructions.	Trainer, training organisation, professional bodies, trade union, the entire engineering industry.	Trainees must be fully engaged in a reputable organisation, learning and working as full-time staff under a realistic working environment, supervised by an experienced senior officer who is the industry supervisor.
STAGE 5: MANAGE A PROJECT			
Description	**Activities**	**Who is Responsible for Outcome**	
After completing an industrial training, this stage requires the trainee to manage and lead the execution of a live project. Certification can be issued before or after this stage.	The trainee can lead the management of a live engineering project. S/he might decide to regularly consult his/her mentor, the trainer or training institute, if need be.	Trainee, trainer	Trainees can lead an engineering management team to express their developed or improved EMSC freely without instruction or observation, just consultation, if need be.

Table 8.5 EMSC-DF



Legends: *Trainers to determine duration which ranges from 1 -30 days to at most 6 months depending on the number of EMSC. PCO: Professional and Corporate Organization*
Fig.8.1 EMSC Development Framework for engineering managers in Nigeria

IV. Discussion

Guidelines Supporting the EMSC- DF

4.2.1. General Steps
Step 1: Assess Performance
At this step of the EMSC development process, the most experienced and senior manager or an external consultant will act as the assessor of the manager.
The competencies of the manager are assessed and profiled using the EMSC-DF as the baseline competencies required. The EMSC-DF is designed to apply generically to all managers, irrespective of the project's nature, size, type or complexity. The purpose of Step1 is to identify a manager's areas of strength and where further EMSC-DF is required.
After the introductory education, a measurement and review of the trainee's performance is carried out to assess the top most important EMSC-DF. Evidence needs to be collected to determine whether the performance criteria of every EMSC have been met. The assessment levels themselves can be defined simply. Levels of performance could, for example, be expressed as: Below Expectation; Meets Expectation; Exceeds Expectation.
Strong EMSC demonstrated by the trainee is identified and noted especially where performance is seen to meet or exceed the EMSC-DF criteria. Skills gap and development needs, where performance results do not meet the EMSC-DF criteria, should similarly be recognized and noted. The results of the assessment and review should be recorded in an Assessment Log.
Wherever shortfall exists, it is necessary to clearly describe this and to define the development needed. If at any time during the assessment process there appears to be a gap in EMSC which is exposing the project currently being managed to risk, the assessor will need to immediately initiate actions to address the gap by highlighting and escalating the gap, the consequences and the urgency through the relevant channel.
Assessment can be individual based against individual performance criteria or group based.
Step 2: Prepare EMSC Development Plan
After the completion of the assessment, an EMSC development plan which prescribes actions to be undertaken by the experienced project manager, skills to be developed, offering the opportunities necessary to achieve the required development, should be prepared. This plan will use the information gathered in Step 1 to address the development needs of the individual manager and to build on existing strengths.
The findings of the assessment should be treated urgently, as there may be issues identified by the assessment that would require immediate corrective action. Also, the plan should be prioritized to address key areas which are most critical to the individual manager and the organization. Once the areas have been prioritized, a realistic timeline for implementation of the plan needs to be established.
Step 3: Implement EMSC Development Plan and Complete Activities
Activities planned in Step 2 are conducted. These activities will need to consider both the priorities, needs, culture of the organisation and those of the ongoing project(s). These activities should be tracked and monitored against the EMSC development plan. The experienced project manager owns this plan and is responsible for delivering the outcomes. The project manager needs to execute and monitor this plan just as a project plan would be executed and monitored.
This process allows development activities and the methods of assessment to be adapted to suit training or performance assessment requirements. The entry and exit points of this process will depend on the objectives of the senior/project manager and/or project organisation.

4.2.2. Guideline for Training and Trainee
I. Training should be conducted with most recent internationally and locally accepted standards and resources, in a supportive environment; and there should be opportunity for interactive and practical sessions for focus groups during training and at intervals.
ii. Training should be more practical and technical, not just theoretical as it is in the current practice. Valuable certificates, recognisable by the professional and corporate organisations, academia, government, and the entire industry, should be awarded after the successful completion of training.
Iii. Training on scheduling and planning, trainees should be made to understand that finances, resources, time, and quality are not only to be controlled but also monitored and properly accounted for, to avoid project failure.
iv. Cost of training should be subsidised and big corporations should statutorily sponsor training as part of their corporate social responsibilities.
v. People with special needs like differently-abled workers who are largely discriminated against in the engineering industry should be adequately protected and catered for in a befitting area of need.

Vi. Understanding the use of computer applications, software and information technology generally should be emphasized. The same guidelines apply for online training and should be followed as such, but arrangements should be made for onsite practical, industrial training, and group assignments.
Vii. Different people with different backgrounds and ideologies are involved in engineering projects. Dialogue, negotiation, diplomacy and a guild of adjudicators must be employed to deal with any conflict or misunderstanding during training and execution of projects.
Viii. The entrepreneurial side of all EMSC should be emphasized to promote independent practice and create job opportunities. Technopreneur, which is the use of the latest and updated technology to train managers and help them create jobs for others through the application of technological innovations, should be adopted in EMSC-DF.
Ix. Managers and supervisors should be encouraged to focus on developing EMSC and gaining experiences, as monetary gains and profits will naturally follow soon. They must be made to first and foremost develop the needed interest and passion for the profession. This prepares and reorients their mind and attitude towards better reception of the knowledge and to become service-oriented.
X. Trainees should be made to understand that training is a continuous process, that knowledge is power and should be constantly updated and knowledge shared as necessary. This is because every profession is a living and growing profession, which means it tends to grow or metamorphose during the evolution of the industry.
xi. Women should be encouraged in the NSE and during training, all forms of gender discrimination should be discouraged in the industry and during training.

4.2.3. Guidelines for the Trainer
i. The trainers, training institutions, and programmes should be improved and equipped for resourceful, updating, and technical training.
ii. There should be clarity of purpose and responsibility in all agreements entered for training. Training should be tailored to suit the EMSC gaps. Skills should also be focused on market demand and needs, and challenges.
Iii. While maintaining global best practice, local creativity, talent and contents should be sourced and encouraged. Trainers should seek to identify the core skill strength of the trainee, advice and build on it individually to improve on career guidance.
iv. The trainer should be purged of all dimensions of sentiments, including the religious, tribal, ethnic, and cultural. These can affect the trainer's sense of judgement and the handling of the beliefs and values of the trainee.
V. Trainers should, while applying these guidelines, study and adopt the code of engineering ethics of Nigerian Society of Engineers (NSE) and that of other professional and corporate organisations (PCO), global best practices and guidelines for training in the industry.

4.2.4. Guidelines for Professional and Corporate Organisations (PCO) Both Public and Private.
I. Private and public organisations should be compelled by the Industrial Training Fund (ITF), as a condition for certification, to update the knowledge, skills and competences of their workforce as deemed necessary by the activities in industry. They should profile their workforce to identify EMSC gaps.
Ii. Organisations should ensure that their trained and experienced managers are attached or assigned a junior or new manager for guidance related to work and career development. The mentor serves as a coach facilitating the continuous professional development of the trainee by helping to identify skills, competence gap and training needs and other professional aspirations. This is knowledge sharing.
iii. Private and public organisations should see the need to hire specialists and experts to train their unskilled workers at little or no direct cost to the workers. They should diversify roles and responsibilities according to task and insist that roles and responsibilities are assigned based on discipline, area of training, and specialization. This will enable and enhance productivity.
iv. There should be more training and seminar awareness through the PCO to get intending trainees informed. Government should empower PCO to jointly monitor the industry, implement and enforce their code of conducts, ethical standards and possibly, the framework developed through this study.
v. There is a need for discussions and Interactions among colleagues and senior professionals in construction management to acquire more knowledge and share experience. More experienced managers should be encouraged to pass on their knowledge to younger managers before and after retirement. Technical excursions, as currently practised by NSE branches nationwide, should be encouraged and improved on. International industrial training as annually practised by NSE, should be sustained and enhanced.
vi. Professional construction organisations should work with government and local authorities to secure project and training sites in a non-volatile part of the country. They should sponsor, help enact and enforce all necessary legislations, policies, and regulations. All cultural, religious and traditional norms and values of the locality must be taken into consideration at the planning and execution of training and projects.
vii. Government and organisations should work together to approve study or training leave with pay and allowances for any manager or supervisor who requests to embark on any relevant training. PCO should compel

members not to leave an organisation for a minimum of two years after being trained by such an organisation, especially, where the training is sponsored by the said organisation. Where it is unavoidable, training remuneration should be settled and refunded to the employer before the worker can leave.

viii. Government through her agencies like COREN, ARCON, COBON and professional construction organisations like NSE, NICE, NIA, NIOB and others, should harmonise and issue renewable licences of practice to any individual or organisation that intends to and is qualified to establish an EMSC training centre.

iv. Professional and corporate organisations should investigate and do more to protect the integrity of the profession and the interest of their members by ensuring that the quality and cost of training delivered by trainers are of best possible value, creation and protection of jobs, especially, those lost to quacks through unenforced policies and legislations.

x. This study, just like Zou and Sunindijo (2013), suggests that organisations incorporate the training of at least the top EMSC, and knowledge sharing policy in their human resource development programmes and that tertiary education institutions also consider these EMSC in their engineering management related curriculum.

V. Conclusion

The EMSC-DF, developed through a rigorous process of literature review, industry interviews, and validation, offers a structured approach to enhancing engineering management skills and competencies. The framework provides a valuable tool for organizations to develop their engineering managers and for individuals to guide their professional development. The supporting guidelines offer practical advice on implementing the framework. The research contributes to the body of knowledge on engineering management by providing an empirically validated framework that can be adapted to various industrial contexts. Future research could focus on evaluating the effectiveness of the EMSC-DF in improving engineering management performance and on exploring its applicability in different cultural and organizational settings.

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