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A Review of Six Sigma and the Shared Relationship with Knowledge Management (KM) Discipline

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ABSTRACT

Six Sigma and KM are two distinct disciplines that support each other, and subsequently, create a strong foundation for learning when used concurrently in an organizational context. Although, six sigma objectives tend towards process improvement while KM objective is all about the right flow of information and knowledge, however, there is a very powerful intersection and synergy between the two disciplines that promote process performance. The reported cases on failed six sigma projects have been on the rise, due to organization's inability to create a learning environment, fit enough to engage employee's capabilities in solving quality related problems such that knowledge of the process is retained and not lost after the six sigma project. Recently, very few organizations are now acquainting themselves with these two notable improvement strategies in quest of becoming more ambidextrous to positively frame process problem as an opportunity for improvement. This paper explored the potentials of these two disciplines, by taking a narrative review both from the academic and in the practitioner's point of view to bring to limelight their level of synergy and appreciation both in scholarly and in organizational domain. This study has underscored the level of awareness and poor utilization of these two disciplines in improving organizational performance among manufacturing firms. The paper further expounds on the need for organizations to focus in building an organic knowledge structure that will favourably sustain

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newly-stabilized processes, and also suggest for more integration of both disciplines since there is no standardized model(s) of integration of six sigma-DMAIC and KM to widely capture knowledge on other integration tactics.

Keywords: Six sigma; km; cop; quality management; process improvement.

1. INTRODUCTION

Although six sigma's team-approach of problem-solving has in its five-phase implementation stages and framework fit to create and retain knowledge, yet most of the process knowledge shared during process improvement project is always not captured, and most of the captured knowledge is poorly retained. Hence, transfer of best practices becomes difficult and more expensive when there are no common communities of practitioners capable of creating, retaining and sustaining the acquired knowledge. Although, through six sigma, organizations can realize technical innovation and corporate culture formation, but the number of challenges that present themselves in today's economy is causing six sigma firms to take an increased interest in KM, probably because of the aging workforce, rapid advance in technology, service retrenchment and retirement [1]. Due to knowledge lost, most organizations are adapting knowledge-based management system to their existing methodology to get in line with this trending global sustenance practice. Some researchers are of the opinion that six sigma improvement approaches are at the risk of failing unless supported by the appropriate behaviour changing mechanism. It is becoming a tenet among quality proponents that organizations cannot focus on implementing six sigma in isolation of a behaviour-focused approach to sustain behavioural change among its employees. Alternatively, the future of six sigma depends on whether it is capable of absorbing and integrating other management thinking and tools to further it prowess [2]. Despite the popularity of six sigma programs, there is little theoretical support on the effectiveness of six sigma projects on organizational performance [3]. Its ability to achieve both efficiency and innovation has been challenged from different perspectives. Six Sigma programs have shown little evidence of its capabilities to deal with behavioural and change processes [4]. A further concern is on its potency to address improvement in decision-making and communication since they are designed to deal with specific quantifiable and measurable improvement goals. Analyzing Six sigma DMAIC

from a perspective of a problem-solving approach is a weak guide for less routine projects, in which human-dynamics; subjective perceptions and personal values are important aspects [5]. Most of these six sigma limitations have been highlighted in the works of many quality management scholars, thus creating opportunities for future studies. However, it is so disparaging up till now, that the innate benefits of these two disciplines have not been practically explored to organizational advantage, and most organizations even outsource process improvement projects entirely to external practitioners external without giving attempt to build a knowledge structure that will favourably sustain newly-stabilized processes.

On the other hand, just as earlier observed in six sigma strategies, KM also has its own functional implementation plagues. Among the obstacles attributed to KM implementation, are linked to cultural issues [6], inability to identify the knowledge domain possessing potential value in organizations [7], and ways to convert perceived knowledge into actual value [1]. In addition, there is no absolute method for measuring KM organization, which is also acknowledged as a challenge [8]. It was obvious from the extant literature that huge knowledge lost in six sigma projects could have been retained if KM potentials are well enabled. Poor utilization of these two distinct disciplines has been distinctively shown on the existing process improvement literature, and myriads of challenges faced over the years by a good number of organizations that had embarked on quality development projects have been on how to transfer best practices, be innovative and sustain an improved system.

In this paper, a careful revision was made on these two contentious subjects; six sigma and KM, narrowing down on their backgrounds, innate potentials, weaknesses and level of awareness among quality professionals. Much emphasis on this review is directed to their conceived positive contributions and influence on the organic side of organizational development, and effects on the overall system performance. The level of appreciation of these disciplines in a

global perspective was properly described, and domains for future studies were clearly highlighted based on the acknowledged needs in order to narrow the existing gaps in these two subject domain.

2. RESEARCH METHODOLOGY

This paper took a narrative review of these two distinct subjects; KM and six sigma methodology, both from the academic and in the practitioner's point of view. The searches for the reviewed literature were not limited by years of publication or region but were based on the available literature that is relevant to the subjects. The selected literature was summarized on the basis of their existing theories, models, and contributions to overall organizational performance. The results as described in this study were based on a qualitative level.

3. SIX SIGMA DEVELOPMENTS AND IMPLEMENTATION

This quality improvement programme was developed by Motorola engineers in 1986, and their quality improvement goals were set such that process variability is at ± 6 S.D. from the process mean, signifying that customer specifications are met and can only produce 3.4 non-conforming products. In six sigma structured improvement procedure, we have two known methodology DMAIC and DMADV. These two are most commonly used six sigma methodologies used to attain a single goal under different circumstances and problem areas. DMAIC is an acronym for Define, Measure, Analyze, Improve, and Control.

The essence of DMAIC method is to reduce variation in a process to achieve high

conformance quality in customer's terms. Six Sigma DMAIC approach of continuous improvement facilitate change on a steady and progressive basis [9] and work within the framework of the existing processes. On the other hand, DMADV is an incorporation of more innovative tools such as the theory of creative problem-solving and axiomatic design which DMAIC does not [10]. Additionally, DMADV is suitable when a new process is required to assist an organization to achieve a strategic objective, or when a current process is irreparably broken [11].

A uniform way to implement six sigma usually remains a myth as six sigma implementation processes and styles differ from company to company, country to country due to the uniqueness of experiences and nature of problems [12]. Six Sigma initiatives are not very effective in dynamic environments, where the rate of technological change is dramatic [3]. Reportedly, six sigma has been successfully applied in manufacturing organizations such as GE, Boeing, Dupont, Toshiba, Seagate, Kodak, Honeywell, Texas Instruments, Sony, and Ford. Allied-Signal, a technology, and manufacturing company applied six sigma principles to design recertification of aircraft engines in the 1990s and were able to save more than \$600 million in 1991 [13]. Six Sigma based methodology has been used to optimize the variables of SAW Boom machine operational process [14] thus, increasing the sigma level from 1.8 to 3. In automotive designs, six sigma methodologies were applied to reduce the average motor speed variation during Pulse-width Modulation (PWM) control [15]. The DMAIC approach has been utilized in a food manufacturing company to decrease the defect rate of small custard buns by 70% from the baseline to its entitlement [16].

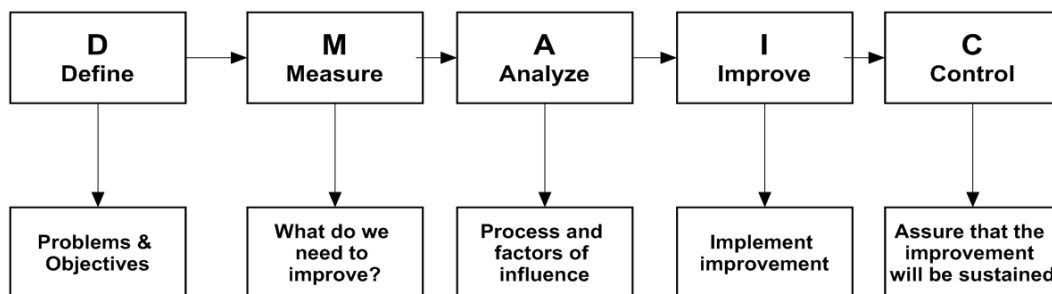


Fig. 1. Six sigma-DMAIC methodology

(Adapted from http://www.optiontrain.com/Lean_Six_Sigma_Green_Belt_Certification_Training.php)

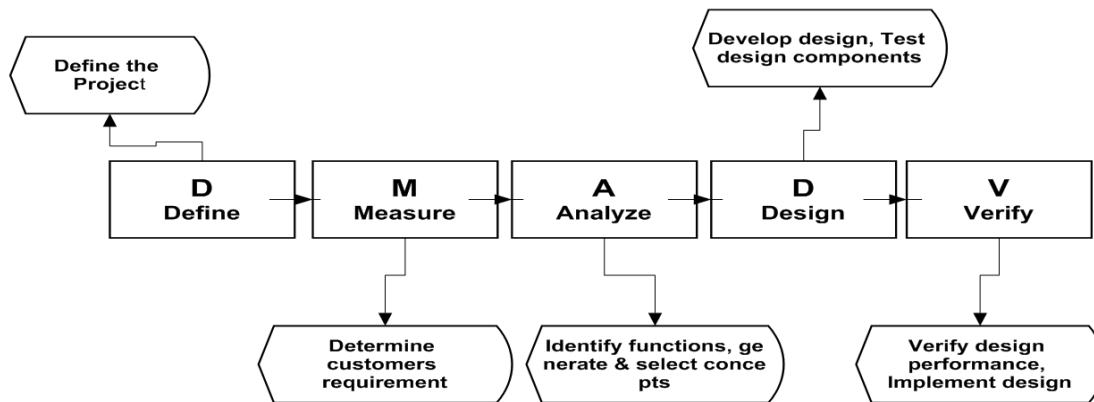


Fig. 2. Six sigma-DMADV methodology

((Adapted from <https://theblogspotblog.wordpress.com/2014/02/18/six-sigma-methodology/>)).

In a textile industry, six sigma-DMAIC methodology was used to improve yarn quality [17]. Similarly, this DMAIC methodology has also been used to reduce defects in a fine grinding process of an automotive company from 16.6 to 1.19% [18]. A reduced amount of defect was achieved in a rubber gloves manufacturing industry through the application of six sigma methodologies [19]. Although the original focus of six sigma was on manufacturing, it has been applied in a non-manufacturing context with minor adaptations [20]. Six Sigma application has also been extended to service industries supply chain [21], financial sectors [22], healthcare, [23], legal service organizations, [24] Engineering and construction [25], as well as in telecommunication [26].

4. SIX SIGMA INTEGRATIONS WITH OTHER QUALITY MANAGEMENT INITIATIVES

Sustainable results can only be achieved when an integrated and cohesive approach is adopted with respect to training and learning [27]. A research call was made for six sigma integrations to help practitioners identify a robust set of improvement tools to be used in conjunction with the DMAIC process [28]. However, most of the reported integrations fail to take full advantage of each methodology due to organizational constraints/philosophy. Six sigma owes its continuing popularity to continual integration with whatever methodology a particular industry finds useful in achieving an excellent approach that none of the lone components is able to match [2]. In recent time, a lot of studies that focused on the shared relationship between six sigma and other innovative management and practices are as

follows; integrating and comparing principles and characteristic of six sigma with Total Quality Management [29,30], integrating and comparing principles and characteristics of six sigma with human resource functions [31], integrating with the theory of constraints [32], integrating with lean production [17,32,33,34,35,36,37,38,39,40,41,42,43,44,45,46] integrating with Balanced score card SCOR model [47], integrating Six Sigma with ISO 9000 [48]; Integrating with ISO 9001 [49]; and integrating six sigma with the capability maturity model [50] are all part of the quality community's effort to maximize the positive effect of the six sigma method. However, common integration challenge is pointing on how to create the organizational infrastructure to support each of these methods and also aligning these infrastructures so that the integrated initiatives are complementary. A specified number of additional research projects using contingency theory, organizational learning, and organization change theories were suggested in order to ensure that organizations' innovation processes are not hindered [51].

5. SIX SIGMA AND ORGANIZATIONAL SUSTENANCE

DMAIC is applicable to empirical problems varying from well-structured to semi-structured, but not to ill-structured problems or pluralistic messes of subjective problems [5]. Consequently, it is seen among the conventional quality proponents as highly methodical with strong statistical underpins, in other words, its ability to address behavioural change is highly doubted. Put differently, six sigma's problem-solving approach can help frame behaviour, since judgments are made based on validated

approach other than by mere forecast. On a different perspective, some researchers also believed six sigma can positively enhance both exploitation and exploration. The actual face-off between exploitation and exploration lies on the measurements accuracy and predictions. Exploration ideas are a bit too radical to be accurately measured in six sigma project, and in six sigma projects, the emphasis is on accurate measurements. "Although six sigma is generally seen as an exploitative activity, it can still co-exist with innovation" [52]. Alternatively, six sigma has an indirect influence on performance through exploitation and exploration [53]. In other words, maintaining an appropriate balance between exploration and exploitation is a primary factor in system survival and prosperity. Recently, operation management scholars have recognized that incorporating human behaviour into operation management models yields more realistic insight [54]. As regards to organizational learning, the difficulties in matching exploration and exploitation are shown in otherness made amid maturity of old technology and creation of current ones [55,56]. Operations management should not be understood as a purely technical problem but must be considered simultaneously with behavioural underpinnings [57]. Recent studies have now re-focused research attention to incorporate psychological, and contextual human side of six sigma [58], goal setting [59], organizational context, and psychological safety [60]. Incorporating six sigma methodology with other strategic and tactical approaches has been much debated in the literature [27], and six sigma benefits can be sustained through instituting a formidable mechanism to address product innovation, cultural change, and environmental uncertainty.

6. CONFRONTATIONAL CONCERNS ON SIX SIGMA IMPROVEMENT STRATEGIES

There is a need to better understand organizational and contextual variables that facilitate or impede effective implementation of six sigma. There is a little theoretical support on the effectiveness of six sigma projects on organizational achievements, and the existing literature seems to suggest that six sigma may hinder an organization's effort to be innovative. Six sigma challenges are multidimensional due to many reasons, ranging from management commitment, the bottom-up and top-down communication mechanisms, unrealistic expectations, inappropriate resources,

inappropriate projects, problem definitions and failure to sustain the results of six sigma projects [27]. In aerospace companies' documentary [61], less than 50% of the respondents were satisfied with their six sigma programs. A similar report in healthcare companies revealed that 54% of the surveyed subjects do not intend to embrace six sigma programs [62]. Organizations such as 3M and Home Depot were not satisfied with their implementation of six sigma programs [63]. However, the ability of six sigma to achieve both efficiency and innovation has been challenged from different perspectives, which most researchers have argued that the utilization of process management methodologies favours exploitative innovation at the expense of eliminating explorative innovation. With much emphasis on process improvement and variance reduction, six sigma would impede product innovation and radical change [3]. As a spin-off of quality management, six sigma maintains a strong emphasis on setting specific goals [57], and as a result of this, cannot address the core principles of quality management such as learning the culture and system view of the organization [64]. It was also observed from the literature review that most six sigma organizations fail to develop a shared vision of the methodology and expectations and often do not have an organized six sigma approach. To achieve the maximum benefits inherent in the six sigma approaches in terms of continuous improvement and sustainability, the approach needs to be integrated with other strategic frameworks like KM that are targeted towards achieving corporate sustainability.

7. KNOWLEDGE MANAGEMENT (KM)

"KM is the process of creating, capturing, and using knowledge to enhance organizational performance" [65]. Knowledge should be appropriately manipulated and shared to consistently multiply cost savings [66]. Knowledge is increased through interaction with information, typically from other people [67]. An organizational competitive advantage is aligned with proper management of knowledge, and organizations are recently leveraging their knowledge wealth to bring forth organizational expectations [68]. In addition to the prior assertion, organizations can achieve competitive advantage only when accurate and important knowledge is transformed, distributed, and integrated. Economic development has always centred on knowledge acquisition and transformation into human capital [69].

	TACIT KNOWLEDGE	TO	EXPLICIT KNOWLEDGE
TACIT KNOWLEDGE TO EXPLICIT KNOWLEDGE	SOCIALISATION (sharing experiences with others)		EXTERNALISATION (writing down tacit knowledge)
	INTERNALISATION (Learning by doing)		COMBINATION (Systemizing it into a knowledge system)

Fig. 3. Organizational knowledge creation (Nonaka, 1997)

Organizations that generate new knowledge and distribute it broadly throughout the organization and rapidly embody it into new technologies and products are considered successful [70]. However, management of knowledge in tacit order including its capturing, maintenance and sharing over different areas is still not efficiently solved in industrial practice [71]. Recent information technology growth has awakened people and organizations in realizing the power of knowledge and the need of harnessing it to enhance long-term organizational performance. The principal reasons for the continued KM importance are linked to the globalization of business, technological advances, workforce dynamism and organizational survival. Managing knowledge effectively entails proper coordination of these four key components: knowledge, people, processes and Technology [72]. Individual knowledge can be converted to group knowledge through active communication and adequate feedback mechanism. Active interaction brings about what is called the four modes of knowledge conversion that occurs through socialization, externalization, combination, and internalization [73].

8. KNOWLEDGE MANAGEMENT VIEWPOINT

There are two main aspects of KM, namely information management and people management. Analyzing from these perspectives, KM is about information on one hand, and people on the other hand. The information management approach, view KM as a process of identifying empirically validated facts and the key KM initiatives. Under this include IT infrastructure, data warehouses and virtual centers of expertise, and other technical procedures. It has been brought out that technology or information management alone is

not enough to drive an organization, but its people/staff and the knowledge that resides within their working environment [74]. The organic view emphasizes the role of people, group dynamics, social and cultural factors, and networks [75]. People create and share knowledge, and for this reason, managing the persons who have the intention to create and share their knowledge is considered very important. Employees are significant part of knowledge management in organizations because they are the source of creativeness. Oddly, most organizations tend to invest majorly on technology in an attempt to enhance performance than in their employees. Such organizations have reportedly ended up with undesirable results when their employees find it uneasy to use these decorated technology systems. Some of these organic approaches include self-service, networks, and communication of practice (CoP), and the transfer of best practices. Networks and community of practice (CoP) are the most vibrant and powerful KM approach used in quality management initiatives. Impact of other process improvement strategies are enhanced as a result of due cognizance to proper KM [76]. However, no general approach to managing knowledge has been commonly accepted up till now [77]; [76], but the success of its implementation is achieved by modifying an organization's culture in ways that encourage and support desired knowledge attitudes and behaviors. General consideration of people that possess the desired tacit knowledge is essential such that their cultural and social values, attitudes and aspirations, likes and dislikes are effectively managed. More success on KM program lies with apt alignment with the business goal, and without which it's a futile exercise [78].

9. KNOWLEDGE MANAGEMENT CRITICAL SUCCESS FACTORS (CSF)

A suitable KM should be well adjusted to the situation and context of the organization in hand [79]; [80]. The key success factors that can enhance deployment of KM practices in an organization include; strong link to business objectives, a compelling vision and structure, knowledge leadership, well-developed technology infrastructure and systematic organizational knowledge processes, a knowledge creating and sharing culture, and continuous learning [81]. In an exploratory study on 31 KM projects, KM success were aligned to a clear link to economic value, a clear purpose and language, multiple channels for knowledge transfer, a standard and flexible knowledge structure, a knowledge-friendly culture, change in motivational practices, senior management support, a technical and organizational infrastructure [82]. Six vital CSFs were proposed to make KM successful in organizations [79]. These suggestions were on; committed senior management leadership, the presence of chief knowledge officer (CKO) and KM infrastructure, knowledge source, incentives, supportive culture, and lastly Km system and tools. Again; a more comprehensive model of eleven factors for implementing KM but in this case was proposed with more emphasis on Small-and-medium Enterprises [7]. These factors are; management leadership and support, culture, IT; strategy and purpose; measurement; organizational infrastructure, processes, and activities; motivational aids; resources; training and education; and Human Resource Management. Note, in terms of incentives and rewards, linking rewards solely to individual performance or outcome will result to unhealthy competition and will be detrimental to knowledge sharing culture [7], and organizations should also permit individuals to query existing practice and to take actions through empowerment [83].

10. PRACTICAL CONCERNS ON KM FUNCTIONS

The common challenge concerning KM is that the actual situation is unique in every organization [84], and there is still no absolute method for measuring KM organization [8]. Other problems faced by KM functions are attributed to culture, organizational structure, trust, job security. Cultural issues are the largest obstacles to implementing successful KM strategies [6,7]. A

culture that supports KM are ones that hold the knowledge to a high esteem and inspire its formation, dissemination, and application. A common cultural aspect that is vital to KM is collaboration [85], thus knowledge transfer requires individual to come together to interact, exchange ideas and share knowledge with one another [7]. The second challenge is in identifying those knowledge domains possessing potential value for the firm and ways of converting them into actual value because most individuals that possess unique knowledge hold a monopolistic power and are reluctant to relinquish that power [86]. Another most influential barrier to the flow of knowledge is lack of communication between functions in the company. Lastly is security; as most of the employees hide valuable knowledge that can equip them as better entrepreneurs, if their job is threatened. In other words, most organizations are reluctant to engage in KM because they are afraid that some vital organizational information will be compromised. However, trust and openness are commonly cited as two values that promote KM behaviours [87]. There is this subject perception among some individuals mainly in manufacturing firms that hoarding knowledge makes them exceptional and indispensable, and this is a barrier to cultural change and impedance to knowledge circulation. By accessing, sharing, and implementing both explicit and tacit knowledge, organizations can influence behaviour and achieve improved performance both individually and as an organization. The more effective organizations are in learning, the more likely they will be at being innovative [88]. However, KM just like other management strategies has their own common pitfalls. Furthermore, reports based on the IBM Institute for Knowledge-Based Organization findings [89], outlined five most important drawbacks that organizations always faced with implementing KM program. The identified drawbacks are highlighted as follows:

1. Overemphasis on formal learning efforts as a mechanism for sharing knowledge.
2. Failure to understand and connect KM into individual's daily work activities.
3. Creation of knowledge repository without addressing the need to manage the content.
4. Failure to align KM efforts with the organization's strategic objectives.
5. Focusing KM efforts only within organizational boundaries.

11. KNOWLEDGE CREATION WITHIN SIX SIGMA QUALITY MANAGEMENT

Learning and knowledge creation in quality improvement relate to how an organization manages the cognitive processes of its members [90]. The relationship with organizational cognition is critical because how a quality program successfully changes practices in an organization depends on how the cognitive processes of its organizational members are managed [91]. Understanding six sigma project from a KM perspective can be useful as six sigma programs facilitate knowledge creation process through the socialization, externalization, combination, and internalization [92]. Six Sigma and KM perspectives reflect the dual emphasis of technical and social dimensions. The technical dimension requires having a method built on the efficient process and cumulative experience acquired through a repetitive structured process. On the other hand, the social dimension puts more emphasis on the social environment in knowledge creation, by designing a creative environment for organizational members. In six sigma projects, for example, the team members comprising of experts and regular workers are closely connected with the affected process. In this team collaboration, these experts now share tacit knowledge with the rest of the group, so a common understanding of the entire process is gained. Recent research interests on six sigma and practical implementation with other management models and methods have heightened the need for organizations to establish and adopt sustainable management models to mould individual behaviours to organizational benefits. Six sigma integrations with other management models and methods have become the focal subject of debate among the circles of quality improvement proponents. Recent un-impressive records on failed six sigma projects globally have awakened most quality improvement proponents to engage in concerted research efforts to unravel answers to poor six sigma project executions. A concerted research effort has linked six sigma failures to organizations inability to retain knowledge and sustain learning environment [93]; [94]; [3]; [27]. Experiences in the literature, concerning companies that have implemented six sigma techniques, without creating the underlying culture of learning, begot the era of shared relationship between six sigma and KM integration. The quest for establishing corporate and sustainable management models starts to gain wider recognition in the last decade, thus

the era of propositions in six sigma-KM integration subjects swoops more ground in quality improvement palace. In this way, understanding six sigma-KM complementary functions can help organizations gain more insight about how to create, retain, and diffuse knowledge using a structural approach [60].

12. RECENT WORKS ON SIX SIGMA AND KM INTEGRATION

Six Sigma and KM cooperation are quickly creeping into the corporate environment with a varying form of integration tactics. Due to the integral exploration of these two distinct disciplines, a lot of organization has made tremendous savings in terms of cost and resources. Few recent works on six sigma and KM integration have been reported in the literature. Simultaneously, KM and six sigma approaches were deployed to solve a specific problem in a hospital [95]. In the same vein, this same concept was also deployed in a textile manufacturing company to solve a quality related problem [96]. Some of the recently proposed six sigma and KM integrations, as well as their individual shortcomings, are highlighted below:

1. Proposed integrated Knowledge representation (IKR) model [97]. The proposed model has very little interaction with the basic six sigma steps. Its Complex-IT platform and budgetary set-up made it more conducive to only large organizations.
2. Proposed Process-based knowledge creation and opportunities model [98]. In this proposed model, the KM process is vague and not clearly described.
3. A proposed Integrated PRAND MODEL [27]. The idea of the model is to have a specialized process research development team in the company. This idea of having a specialized team may deter organizations at a teething quality management level from adopting due to the presumed high resource requirements.
4. Proposed SEIC/SIPOC Continuous Loop model [99]. KM process was not distinctively highlighted, except the knowledge conversion processes.
5. Proposed Knowledge flow in Chinese six sigma team model [100]. Only Chinese cultural environment was considered, and KM procedures were not well described.

The rationales for further studies on six sigma subjects are highlighted underneath with each paragraph describing a specific need.

1. Firstly, there is a limited report both in the academic and in the practitioner's literature regarding successful implementation of six sigma strategies in other parts of the world apart from reported cases in United State, and Western Europe. However, due to the geographical span of various organizations, further, six sigma studies are required in other parts of the world to gain more insights into cultural issues and other co-factors that may affect the six sigma implementations.
2. Different organizations have the different maturity level of quality management implementation, and the potency and pitfalls of their existing quality management systems co-precipitate the need to explore other ways six sigma practices are adapted in different organizational contexts.
3. Six Sigma implementation processes and styles differ from company to company, country to country due to the uniqueness of experiences and nature of problems [12]. More suggestions were further made for more globalization of six sigma and greater Integration of the six sigma ideas and methods into the normal operations of companies, rather than managing six sigma as a lone initiative[101,102].
4. The President, "American Productivity and Quality Centre (APQC)"(as cited [103], pointed out that the human approach of KM specifically the CoP's is not used significantly enough and could be part of the reasons with the replication of findings from previous six sigma projects.

Although some companies like Halliburton, Compaq (now Hp) had benefitted from KM six sigma DMAIC forms of integration but the style in which these integrations were employed in these organizations were not made available in the existing literature. As a result of these, and many more co-factors, the need for more integration on KM and Six Sigma approach becomes imminent to widely capture knowledge on other integration tactics.

13. CONCLUSION

Deducting from the huge body of literature, it becomes obvious that most of the recorded

success stories in the six sigma implementation as described in the literature were in the US, and western countries and most of the hard-earned six sigma results were not properly sustained in the long-run. Reportedly from this review work, it is clearly seen that most six sigma failures are as a result of most process owner's inability to sustain a learning environment and the human side of the process development. This study has reportedly underscored the level of six sigma spread, acknowledging that most of the documented cases of six sigma implementation programs were in a few parts of the world. Furthermore, findings from the review have also disclosed the need for more six sigma integrations with other existing innovative management practices to make good with some of the identified challenges that plague lone six sigma initiative. To this end, this study revealed the need and areas for further research to enhance six sigma disciplines in addressing some of the weaknesses that are encountered in the lone use of the six sigma methodology.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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