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Effective Knowledge Creation in Kaizen Routines

Nur Amalina Muhammad, Jeng Feng Chin

School of Mechanical Engineering, Universiti Sains Malaysia Engineering Campus, 14300 Nibong Tebal, Penang, Malaysia.
*Corresponding Author: chinjengfeng@usm.my

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Abstract: Kaizen is a team-based continuous improvement system in the Lean Six Sigma (LSS) organisations. No study of knowledge creation has been done at the routine level of Kaizen. To fill the gap, the study chooses five common routines in Kaizen, namely, meeting, Gemba, mentoring, coaching, and referencing. It enhances these routines to improve knowledge creation. Sixteen case studies in a manufacturing organisation, with half of them adopting the enhancement routines, are then studied and compared in terms of technical and social system measures related to knowledge creation. Data collection includes direct observation, data logging, and questionnaire surveys. The enhanced Kaizen routines were shown to have significantly outperformed its counterparts in knowledge creation. Meeting and Gemba were the most significant routines to knowledge creation, whereas referencing was the least. The study offers insights into the roles of different Kaizen routines and suggests practical enhancements that can be adopted by LSS organisations to effectuate knowledge creation.

Keywords: *Kaizen, Routines, Knowledge Creation, Lean Six Sigma, Case Studies.*

1. Introduction

LSS integrates concepts from the Lean Manufacturing and Six Sigma [1]. Lean Manufacturing originates from the Toyota Production System (TPS) by Taiichi Ohno and later embraced by the western countries [2]. Lean manufacturing focuses on continuous improvement and waste elimination [3]. By contrast, the Six Sigma quality improvement methodology was invented by Motorola in the mid-1980s. The methodology is data-driven to optimise the process by minimizing its variation. Succinctly, a six-sigma level of quality (process capability) suggests 3.4 defects per millions of opportunities in the process [4]. Many studies show that Lean manufacturing and Six Sigma are mutually complementing concepts and as a hybrid, is useful to improve various organisation performances, such as quality, timely delivery, cost, customer satisfaction, organisation capability, and maximising value for stakeholders [5], [6].

In the LSS, Kaizen represents a project-driven approach to induce continuous, small, and incremental changes in organisations [7]. According to [8]'s project classification, Kaizen closely relates to process improvement [9], as it incrementally perfects a process over time in small, carefully thought-out projects. Generally, Kaizen uses either the PDCA or DMAIC methodology, which has different phases and rigor of investigation. PDCA stands for Plan, Do, Check, and Act (A). The plan phase defines and breaks down a problem, grasps the current condition, establishes a target condition, analyses gap, and discovers the root cause and potential countermeasures. Do develops, tests, refines, finalises, and implements countermeasures. Check measures and validates process performance; Act refines, standardises, and stabilises the process, monitors performance, evaluates outcomes, and shares learning. DMAIC comprises five phases: Define, Measure, Analyze, Improve, and Control (C). Define identifies customer and process requirements, project scope, and objectives. Measure sets output, operational, and critical quality

Corresponding Author: Jeng Feng Chin, School of Mechanical Engineering, Universiti Sains Malaysia Engineering Campus 14300 Nibong Tebal Penang, Malaysia. Email: chinjengfeng@usm.my

metrics and analyses measuring systems. The Analyze phase analyses root causes and outcomes. Improve identifies, tests, and implements countermeasures. Control standardises, monitors, and integrates project timeframe changes [11].

Knowledge creation represents a process of generating, amplifying, and crystalizing knowledge, ideas, and best practices in an organisation [12]. In the LSS organisation, Kaizens are taking a pivotal role to create knowledge. It is expected as Kaizen projects run on a regular basis at all levels of an organisation for continuous improvement and are always unique and dependent on the task, composition, and complementary competency of the teams. Breaking down Kaizen would unravel clockwork of regular routines to enable team-based interactions, gather information, make a decision, and share the experience across organisations [13]. Although we may hypothesize that the degree of knowledge creation relies on the configuration of these routines [14],[15], no study links routines to knowledge creation nor investigates methods to enhance knowledge creation in these routines [16].

To support the claim, several recent works of literature are drawn. [17] identified six knowledge creation opportunities in LSS to be customers' voice, management involvement and commitment, change management, infrastructure management, process improvement, and monitoring and measurement. [18] and [19] related interactivities or phases in Kaizen to different knowledge creation modes. Meanwhile, [20] linked Kaizen tools to knowledge creation model. [21] showed that LSS practices, such as failure mode and effect analysis, can trigger knowledge creation. Evidently, these studies focus primarily on knowledge creation in lean tool implementation [20] [21] from the perspective of organisational learning or generally discussing Kaizen as a single entity without zooming into the macro-level such as routines [18] [19]. Their motives may also deviate from the original idea of knowledge creation which aims to describe knowledge conversion more intimately in human interactions.

To fill the gap, the study carries the mission to distinguish a common set of routines in Kaizen, followed by enhancing them in several aspects concerning knowledge creation. To demonstrate that routine configuration affects knowledge creation, comparisons are made on sixteen case studies of completed Kaizen projects in a manufacturing organisation. Data collection was done through direct observation, data logging, and questionnaire survey. Knowledge creation in these case studies is collectively measured using technical and social system measures. This study extends theories in a pioneering effort to associate knowledge creation to LSS from the dimension of routines. The findings offer insights into Kaizen routines' roles with distinct impact on knowledge creation. As knowledge and its dynamics are integral to LSS organisation, the insights are also helpful to LSS practitioners, especially in prescribing guidelines for Kaizen and routines. Given that limitations, knowledge, and knowledge creation are abstract theoretical constructs, the research is subjected to different interpretations and hence agreement. All the case studies are derived from a single production facility. Therefore, the insights are empirical and endemic only to the industry with a similar LSS culture and business setting.

The study proceeds as follows. Section 2 describes the literature review of LSS, knowledge creation, and routines in Kaizen. Section 3 represents the enhancement of routine, and Section 4 describes the case studies of two routine systems. Section 5 presents the results of case studies, and Section 6 elaborates the discussion of findings. Section 7 provides the conclusion, including the implications and future research.

2. Literature review

2.1 Knowledge creation

[22]'s classification of knowledge into tacit and explicit knowledge is widely accepted by mainstream research [23]. Tacit knowledge includes beliefs, creative processes, hunches, individual experience, insights, intuitions, instincts, know-how, perspectives, skills, understanding of future state, and values [24]. Consequently, articulating, expressing, and formalizing them to others are difficult. They travel poorly between organisations and are mostly shared through person-to-person contacts. By contrast, explicit knowledge is knowledge transmitted in the form of formal and systematic language [25]. They are typically stated in clear language formatted in individuals' minds, such as words, pictures, diagrams, computer codes, and procedure manuals. Consequently, they can be stored or managed by knowledge management systems [26]. Nevertheless, interpretations and meanings of explicit knowledge could vary by individual and purpose [21].

[27]'s SECI knowledge creation model presents knowledge creation as a four-mode conversion model between tacit and explicit knowledge: socialisation (S), externalisation (E), combination (C), and internalisation (I). Socialisation delineates sharing by individuals, tacit knowledge such as mental model, technical skills, and experience. Externalisation articulates tacit knowledge into explicit knowledge triggered by dialogue or collective reflection [28]. Combination integrates different explicit knowledge entities and converts explicit knowledge into systematic sets [29]. Internalisation embodies explicit knowledge into individual's tacit knowledge [29]. Iteratively, knowledge creation forms a spiral to amplify knowledge to a higher-level knowledge-creating entity [30] and spreads knowledge from individual to a group, organisation, and broader community [31].

SECI is dynamic and easily altered by the environment, is path-dependent and subject driven [32]. [33] defined Ba as a shared context in interpreting information to become knowledge. The shared context includes interaction among

individuals or between individuals [34] [30] share time and space [35]. [33] proposed four types of Ba to individual modes in the

SECI model, namely, originating Ba associating to socialisation; interacting Ba to externalisation; systemizing Ba to combination, and exercising Ba to internalisation. For example, originating Ba marks the beginning of knowledge creation, where individuals meet face-to-face to share experiences, feelings, and mental models. Interacting Ba can be captured in brainstorming by the cross-functional team to convert individual mental models into standard terms and concepts [17].

2.2 Routines in Kaizen

A systematic literature review was carried out to identify routines in Kaizen. [36] delineated the routines as recurrent patterns consensually validated structure for process and action, distributed by communication and authority among actors (knowledge actors per se) in specific role sets, and operated on by tacit and explicit knowledge. The definition provides a characteristic outline to routine identification. Next, the perusal of 20 relevant pieces of literature marked five common routines within the frame of the characteristics (Table 1), namely, meeting, Gemba, mentoring, coaching, and referencing.

Table 1. The literature of routines and knowledge creation in Kaizen

Routines	L1	L2	L3	L4	L5	L6	L7	L8	L9	L10	L11	L12	L13	L14	L15	L16	L17	L18	L19	L20	Total
Meeting	*	*	*	*			*	*	*	*	*	*	*		*	*	*			*	*15*
Coaching	*	*		*	*		*			*	*		*	*	*		*	*	*		*13*
Mentoring	*	*		*			*	*		*	*		*	*	*			*			*11*
Referencing			*					*		*	*			*					*	*	*7*
Gemba			*	*		*		*			*										*5*

Note: L1: [17]; L2: [43]; L3: [18]; L4: [62]; L5: [44]; L6: [63]; L7: [64]; L8: [65]; L9: [66]; L10: [67]; L11: [42]; L12: [68]; L13: [19]; L14: [69]; L15: [70]; L16: [71]; L17: [38]; L18: [72]; L19: [46]; L20: [31]

Meeting is interactivity when two or more people meet for discussion with shared intention. It associates to socialisation and combination modes when the expert shares mental models and technical skills or when bodies of explicit knowledge are combined [20],[37]. A meeting could be face-to-face in a physical Ba or on remote using a medium in virtual Ba [26]. [38] used progress meeting as a platform to share the latest knowledge to knowledge actors. [31] promoted obeya-oriented practices to present the SECI model in knowledge creation. [39] promoted kick-off meetings before commencing any Kaizen to underline the need for Kaizen and initiate enthusiasm and motivation in the Kaizen team. Gemba means field visit or “go and see” the real place with their own eyes to observe what happens [40]. Gemba is crucial for observation, validation, repeatability study, experiment, and analysis to grasp the observed event's status in Kaizen [41] ,[42]. During Gemba, knowledge actors ask questions and learn [41]. Testing and experimentation, such as pilot runs, are variations to Gemba as these interactivities are often performed in situ or environment emulating the real scenario. Mentoring represents one-to-one interactions between knowledge actor and mentor. The role of a mentor is to assist, align, and incorporate the LSS in an organisation. The mentor guides the team through phases of Kaizen and monitors their learning progress [43], facilitating proper steps to identify knowledge gap, performance, and LSS methodology. Therefore, mentoring pays attention to knowledge creation in procedural knowledge [19], that is, the know-how to do something and the ability to execute action sequences of a task.

Coaching represents interactions between the knowledge actor and champion to harness the project meeting of a goal. Champion is commonly senior executives tasked to formulate organisational strategic plan and ideally backed with a strong Kaizen background [44]. The person is an operation or business specialist with substantial experience in different aspects of organisation and improvement. In coaching, Regular project reviews and briefings enable experience sharing between the champion and Kaizen team [42], inducing reflection and correction [39]. Additionally, the champion removes roadblocks to Kaizen. [45] applied tollgates in coaching and mentoring to review milestones between the major phases in Kaizen. The review would include validating technical tool, information, and project duration about the problem.

Referencing happens when the team refers, benchmarks, or analyzes existing information or materials [18], primarily helped by the prevalence of information system in an organisation. Referencing fosters knowledge creation at individual and collective levels [15]. Extending from referencing, communicating with those familiar with the reference material helps further learning [46].

2.3 Measuring knowledge creation in Kaizen

As Kaizen is a complex organisational phenomenon, knowledge creation could impact technical and social

systems [47] [48]. Technical system measures relate Kaizen's technical performances and in turn reflect the organisational intention, which according to [49], is the most important criterion to judge the truthfulness of a given piece of knowledge. [48] suggested technical system measures including goal achievement, impact on the area, and overall business success. Similarly, in assessing multiple facets of the project's success, [18] included the extent of achieving Kaizen goal, process performance changes, and the immediate and long-term benefits to the organisation.

Social system measures describe the impact of knowledge creation onto human resource performance. According to [73], knowledge delineates the maximal exercise of human judgment, which is the capacity of an individual to draw new distinctions concerning a task based on an appreciation of context or theory. [48] proposed social system measures to include an understanding of subject matter, namely, participating employee attitude and skills.

3. Enhancing knowledge creation in Kaizen routines

This study focuses on five routines: meeting, Gemba, coaching, mentoring, and referencing. We draw inspiration from [49] to enhance knowledge creation in these routines. First, knowledge creation occurs in human interactivity. Therefore, we determine how regular interactivity is affecting knowledge creation. Second, different forms of knowledge could and would be generated in human interactivity. However, useful knowledge lies in its relation to the intention, which also underlines the fundamental value of the organisation. Third, intention keeps the members committed and focused on the problem. Alignment of a personal goal to intention is crucial. Therefore, fourth, learning should be made explicit in defining intention so that a suitable enforcing mechanism is installed throughout Kaizen. Fifth, requisite variety in a team and environment establishes the links to prior knowledge and ensures a dynamic flow of information or knowledge between the team and the environment. Sixth, autonomy allows the members to customise the work setting to improve their collective efficiency and exploration strategy. Knowledge is created when boundary is crossed. In the same token, seventh, fluctuation and creative chaos challenge the members to reflect and revise the existing norms to pursue a breakthrough. Eighth, the SECI models delineate the conversion of tacit and implicit knowledge through human interactivity. The cycle of conversion is not necessarily completed in a single event, such as a routine, but may be extended across several occasions, such as many episodes.

Given the multiplicity of dimension in knowledge creation, we choose to describe only key aspects of the enhancements. These enhancements are synthesised from literature and successive brainstorming sessions among the authors. To keep the autonomy, fluctuation, and creative chaos in perspective, we are mindful not to over-prescribe the enhancement in routines for fear of counter-intuitively constraining knowledge creation. To illustrate these key aspects, we first focus on the Kaizen phases, followed by routine specifics, dialogues to elicit knowledge creation, and finally, the associated knowledge assets.

3.1 Routine specifics

Coordination of routines or set of practices aims to retain the routine's construct and avoid "disruptive chaos" [50]. In this spirit, we define a loose structure of routines which consists of three parts: pre, on, and post phases of a routine. In the pre-phase, the Kaizen leader identifies a routine goal, creates an agenda, arranges venue and time, circulates routine particulars to members, and prepares supporting materials [51],[42]. By receiving information early, the team members would have time to reflect on their actions and the Kaizen progress. Depending on the nature of the routine, specific outcomes are often expected. The outcomes must align with the intention. In addition, the adequacy of the inputs and generating process to these outcomes should commensurate with the project's complexity and urgency. The Kaizen leader should mediate the routine flow and ensure that any decision making should be scientifically well-supported. The Post-phase intends to organize and share findings and follow-up action [52].

Routines must be adjusted circumstantially. In the kick-off (inaugural) meeting, the management representative presents a problem overview, builds a sense of crisis by highlighting the importance of resorting to the problem (about organisational intention), and introducing knowledge actors. Full recognition by top management would grant the team access to company resources and hence provide the requisite variety and redundancy to knowledge creation. In a kick-off meeting, the Kaizen leader must establish ground rules that define the performing team's baseline behaviors. The members must reach a work agreement, meaning to move the group development stages from forming through storming and into norming as early as possible. The Kaizen leader regularly convenes the routine. Close physical interaction is vital in sharing context and forming a common language among individuals. It allows effective coordination of activities and creates a sense of solidarity [53]. Finally, the team presents the work and shares the findings to the organisation in a closure meeting. This process is accompanied by a Gemba to showcase the improvement.

The regular Gemba with a brief interaction with relevant actors on the field is recommended. The person should also identify and pay attention to the shop floor's visual information that could be the relevant source of knowledge. In reference to Section 3, coaching and mentoring hold different responsibilities and focuses.

Tollgate is used as the converging point to the mentor and champion to evaluate the concept as part of the justification process. The Kaizen team would typically provide a progress presentation and milestone review to compare the reality with the expectation and assess decision making's appropriateness. Referencing is required at the planning stage, where existing material (e.g., historical cases or solutions) is explored. They are encouraged to search from the public domain, such as the World Wide Web. Referencing, with or without reference material, must involve interactions with experienced personnel—this process raises referencing into inductive reasoning where relevant cases and experiences are articulated to derive useful findings.

3.2 Use of dialogues

As knowledge creation happens in reflexive social interaction, a dialogue is a vital element in routines. A dialogue is a joint activity between at least two speech partners to exchange verbal messages in turn to fulfil a collective goal, such as to remove their perplexity [54]. Two forms of dialogue are recommended in routines, namely, generative and reflective dialogues. Generative dialogue defines conversation and interacting that breaks ground for a new action to reveal new knowledge that cannot be attained individually [55]. It is fragmented to the group communication that includes learning a new way of relating to issues. Generative dialogue does not only provide tacit knowledge; it also aligns new actions and values and informs decisions [56]. By contrast, reflective dialogue involves group communication facilitated by experts to reflect upon and reason a decision or action and possible alternatives. Therefore, the expert must understand the issues, accepting the other's perspective without feeling the need to agree with it, and provide a reflection on the critical issues based on their knowledge. Additionally, these dialogues' productiveness relies on the modality of relational engagement where individuals actively take care of the joint tasks and the relationships between the parties [57]. Open-minded norms could also foster the relationship between goal cooperativeness and knowledge creation in these dialogues [58].

3.3 Knowledge artefacts

Kaizen's primary knowledge artefacts are the LSS tools such as VSM, cause-and-effect diagram, process flow, 5-why, and effort-impact diagram, to name a few. These tools aid decision making and provide visibility of improvement opportunity, in alignment with the Lean concept. Learning tools (e.g., Pareto analysis, cause-and-effect diagram, and 5-why analysis, etc.) serve both inductive and deductive reasoning. They allow the scientific gathering of evidence, seeking patterns, and forming a conclusion to explain or deduce the problem causes. The Kaizen summary (KS) is a narrative document summarizing knowledge including findings, best practices, and lessons learned throughout the Kaizen. It also stipulates storytelling on the flow of Kaizen by arranging slides according to the Kaizen stage.

4. Case studies

4.1 Company background

Company A is a multi-national corporation in Malaysia with over a thousand employees. Case studies were carried out at its production facility focusing on electronics assembly. Company A produces 17 types of products in three product families. The company is selected owing to the strong rapport our research team has developed with the company. Moreover, the company has structured LSS and Kaizen programs. The company currently has five in-house LSS experts. Permission was obtained from the management to carry out the study. The first author gained access to the company and continued onsite data collection for two years. She arrived at the production facility two months before the study for Black belt training. The duration allows her to learn about the norms, values, and rules of the organisation behavior in the production facility.

4.2 Case studies

This study compares two sets of case studies denoted as S_N and S_K. According to [59], multiple case studies reduce performance variation due to individual agency. In addition, analysis can be made both within each and across cases. Sixteen Kaizens are identified and randomly assigned to S_K and S_N. These Kaizens follow PDCA as the methodology is practiced in the company. Table 2 shows the details of these Kaizens.

S_N represents routines deployed in a crude form, often informally and with little predetermined structure, planning, and overseeing in execution. The conduct of routine in S_N is entirely dependent on the current practices, disposition of the Kaizen leader, and requirement. Given these reasons, routines are rather primitive, contingent, and with little details to be revealed. General prerequisites for S_N are highlighted: forming a Kaizen team, appointing a mentor and champion, and approaching the process owner of the field to acquire information.

In S_K, the Kaizen leaders would be briefed about their roles in this research and how to conduct routines to ensure the standardisation for each routine. The sub-routine is also highlighted during the briefing such as kick-off meetings, daily Gemba, tollgates, and at least one referencing. Open discussion with knowledge leaders was conducted to achieve an enhanced level of understanding before conducting the routine and Kaizen. A logbook was provided to the Kaizen leaders to record their routines. These logbooks have undergone weekly reviews to ensure correct filling of the required details. Finally, the Kaizen summary was compiled.

Kaizen teams were allowed flexibility to arrange

routines under certain conditions such as unavailability of relevant resources (e.g., knowledge actors, space, reference materials, etc.), production halt (e.g., planned and unplanned downtime), and public holidays that may delay or affect the planning of routine. When such conditions prevail, the Kaizen team must be aware of the implication of decision.

4.3 Data collection

4.3.1. Survey on the knowledge creation in routine to technical and system measures

Knowledge creation in routine is measured on the basis of three technical and two social system measures. The technical system measures are the percentage of goals met (TSM1), impact on the area (TSM2), and overall business success (TSM3). TSM1 refers to the attainment of the Kaizen goal in percentage, reflecting the change in interest performance before and after Kaizen. TSM2 measures Kaizen's general impact on people, machines, processes, and product entities in the affected system. TSM3 captures the perception of mentor and champion on Kaizen's success based on overall coordination and execution. Two social system measures are knowledge gain and LSS (SSM1) and idea generation skills and decision making (SSM2). SSM1 refers to the gain of knowledge and experience in LSS. SSM2 refers to the team's competency to devise a feasible solution, ideas for knowledge creation, and the capability to decide on multiple options. These system measures are assessed qualitatively through 1–5 Likert scale (1: Strongly disagree, 2: Disagree, 3: Undecided, 4: Agree, and 5: Strongly agree). Respondents are required to determine each routine's rating to the system measures based on their general observation during these Kaizens (25 questions in total, with five routines to five system measures). The relationship between system measures to knowledge creation is examined through the ANOVA test. P-value (< 0.05) measures the significance of system measures to the knowledge creation, while F-value (> 6) indicates the strength of the significance. The relevant questionnaires are distributed to the Kaizen leaders at project closure, with later follow-up email.

4.3.2. Observational data collection

Data are also collected through direct and indirect observations. The first researcher carries out direct observation. Developing a trusting relationship and helping the knowledge actors feel comfortable during the observation are essential. Before the case study, the knowledge actors would be informed of the study's scope and how they will be watched.

The first researcher will receive the schedule of routines and changes from the Kaizen leaders. During the direct observation, data are captured through several instruments such as written text, photographs, and recording. Moreover, scope for data to be captured is based on information required for data extraction and data analysis.

Indirect observation involves the documentation from knowledge leaders such as logbook and Kaizen summary. Two ways exist in measuring the frequency of routines. For meeting, mentoring, coaching, and referencing, a single occurrence is logged whenever a routine is performed or two routines occur in succession under the same agenda.

The frequency of Gemba is measured in terms of daily running, meaning that the requirement is fulfilled with at least one Gemba performed in a day. When the nature of interactivity shows a significant overlapping of two or more routines, they are logged separately.

5. Results

The researcher attended 50% of routines to ensure that routines are conducted accordingly by knowledge actors. For other routines, the researcher referred to records in the logbook and Kaizen summary. After Kaizen completion, two online surveys are carried out. The first survey asks the

Kaizen team to rank the routines effectively to system measure, and the second survey asks the Kaizen team to rate the routines on the attainment of system measure. Follow-up email is dispatched as a reminder until all responses are received. Only one Kaizen (S_N-P4) failed to achieve the Kaizen goal within the given timeframe. However, top management agreed on its closure, considering the difficulties, timeline, and obstacles confronted in the Kaizen.

5.1. Instances of routines

Figures 1 and 2 show the instances of routines that occurred over the period of Kaizen by weeks in S_N and S_K, respectively. The Kaizen timeframe is divided into two stages: Stage I which consisted of the Plan phase (white color) and Stage II which consisted of the Do, Check, and Act phases (grey color). This division is applied for tollgate in mentoring and coaching. Five key findings noticed from the figures are

a) In S_N, all Kaizens conducted meetings, but only three Kaizens conducted kick-off meetings. In S_K, all Kaizens conducted meetings, including kick-off meetings.
b) In S_N, no Kaizen conducted daily Gemba. In S_K, all Kaizens conducted daily Gemba.
c) In S_N, all Kaizens conducted mentoring without tollgate. In S_K, all Kaizens conducted mentoring, including tollgate.
d) In S_N, all Kaizens conducted coaching without tollgate. In S_K, all Kaizens conducted coaching, including tollgate for both stages.
e) In S_N, two Kaizens conducted referencing. In S_K, seven Kaizen conducted referencing and one Kaizen with no available reference material.

Table 2. Kaizen in S_K and S_N

Kaizen	Kaizen title	Kaizen goal
S_N-P_1	Manual touch up of the reduction in A area.	To reduce manual touch up in A area from 10 to 5 pts. by 25th August 2017.
S_N-P_2	Receiving Process and Put-Away system efficiency improvement in the B area.	To reduce receiving to put-away process lead time in the B area from 33 to 26 hours by 25th August 2017.
S_N-P_3	Tray rejection reduction in the C area.	To reduce rejection of rub marks in the C area from 4,719 to 3,000 DPPM (Defective parts per million) by 2nd September 2017.
S_N-P_4	Material flow efficiency improvement in the E area.	To improve the average utilisation time of material handlers in the E area from 28 to 14 min by 1st September 2017.
S_N-P_5	Production supply waste rate reduction in the D area.	To reduce monthly production supply waste rate in the D area from 0.054 to 0.049 by 25th August 2017.
S_N-P_6	Sampling transportation time in the F area.	To reduce final product audit transportation time in the F area from 27 to 19 min/line/shift by 25th August 2016.
S_N-P_7	Cycle time improvement in the E area.	To reduce cycle time for Heijunka process in the E area from 8.65 to 4.33 h by 25th August 2017.
S_N-P_8	UPH (unit per hour) improvement for Product X in the G area.	To improve UPH (unit per hour) for Products X in the G area from 340 to 370 by 24th August 2017.
S_K-P_1	UPH (unit per hour) improvement of Product XX in the G area.	To improve UPH (unit per hour) of Product XX in the G area from 70 to 110 by 27th August 2018.
S_K-P_2	UPH (unit per hour) improvement for Product XY in the K area.	To improve UPH (unit per hour) of Product XY in the K area from 73 to 90 by 21st August 2018.
S_K-P_3	UPH (unit per hour) improvement for Product XZ in the G area.	To improve UPH (unit per hour) of Product XZ in the G area from 90 to 105 by 24th August 2018.
S_K-P_4	Offload qualification lead time reduction for new product.	To reduce offload qualification lead time for a new product from 17 to 4 weeks by 27th August 2018.
S_K-P_5	Electricity consumption reduction in the E, B, and H areas.	To reduce lighting usage in the E, B, and H areas from 85 to 69 K kWh by 27th August 2018.
S_K-P_6	Bottom-to-top changeover time reduction in the G area.	To reduce bottom-to-top changeover time in the G area from 61.3 to 42.9 min by 21st August 2018.
S_K-P_7	Attrition reduction in the G area.	To reduce attrition in the G area from 0.1189% to 0.06% by 27th August 2018.
S_K-P_8	Weekly maintenance time reduction for Products X and Y in the J area.	1) To reduce weekly maintenance time for Product X in the J area from 9.27 to 6.49 min per 1,000 tested units by 21st September 2018. 2) To reduce weekly maintenance time for Product Y in the J area from 5.71 to 4 min per 1,000 tested units by 21st September 2018.

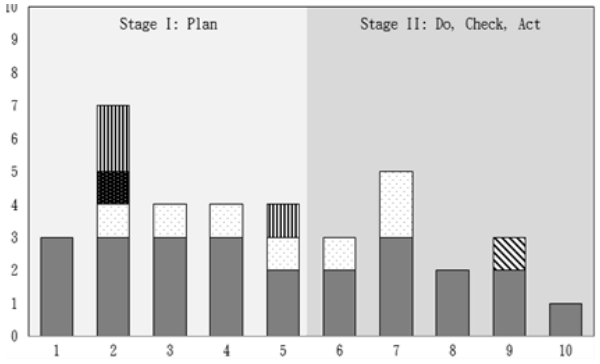

Figure 1(a). S_N-P_1

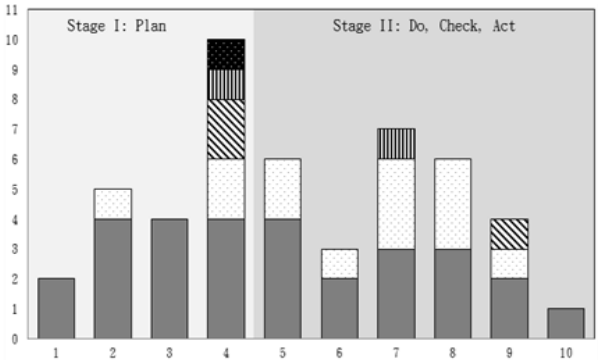

Figure 1(b). S_N-P_2

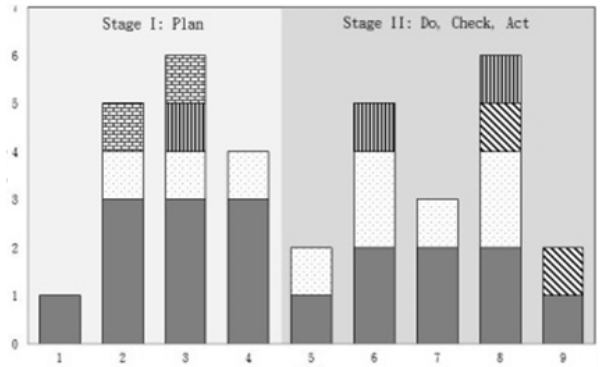

Figure 1(c). S_N-P_3

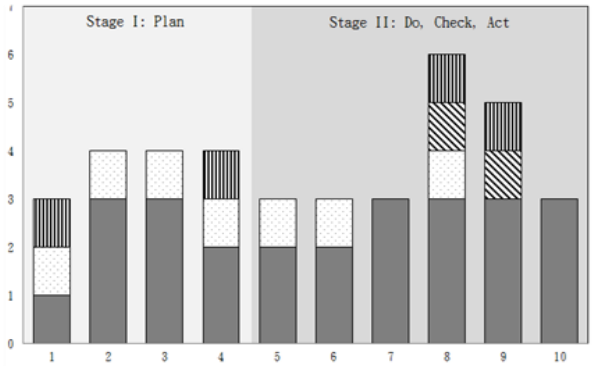

Figure 1(d). S_N-P_4

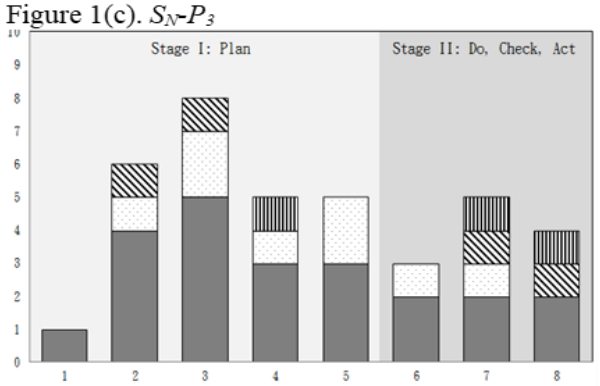

Figure 1(e). S_N-P_5

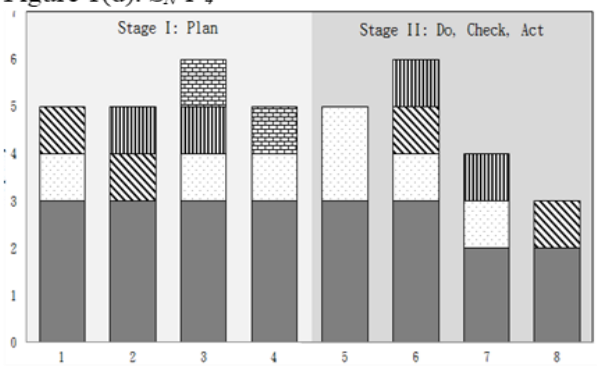

Figure 1(f). S_N-P_6

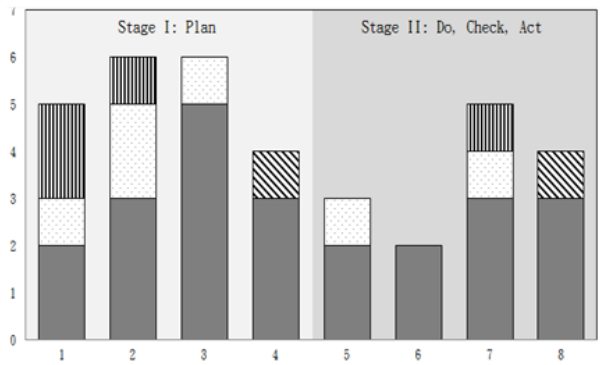

Figure 1(g). S_N-P_7

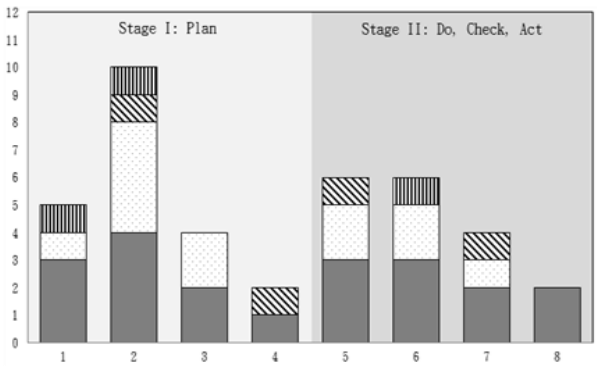

Figure 1(h). S_N-P_8

Figure 1. The instances of routines for S_N

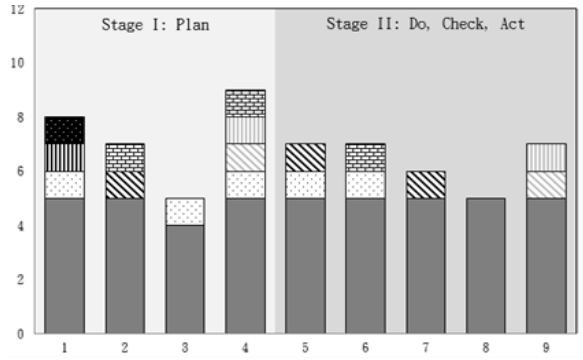

Figure 2(a). S_K-P_1

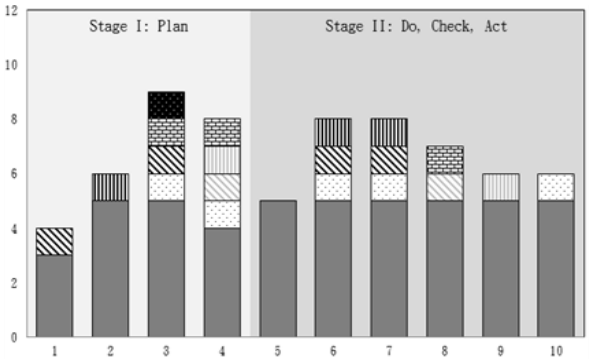

Figure 2(b). S_K-P_2

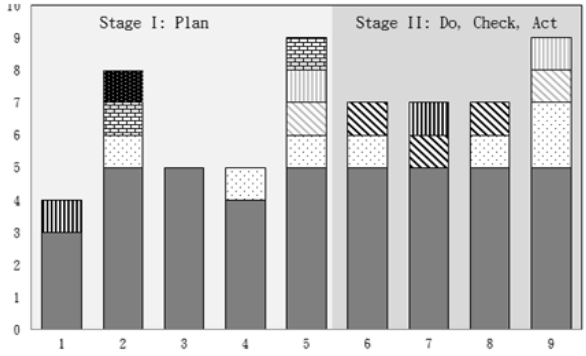

Figure 2(c). S_K-P_3

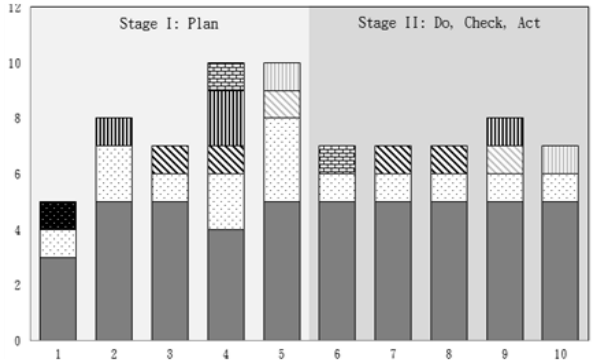

Figure 2(d). S_K-P_4

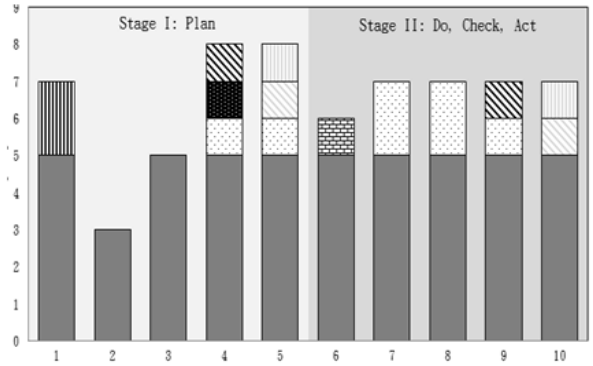

Figure 2(e). S_K-P_5

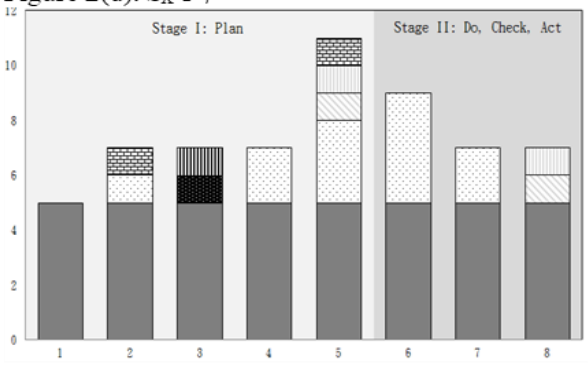

Figure 2(f). S_K-P_6

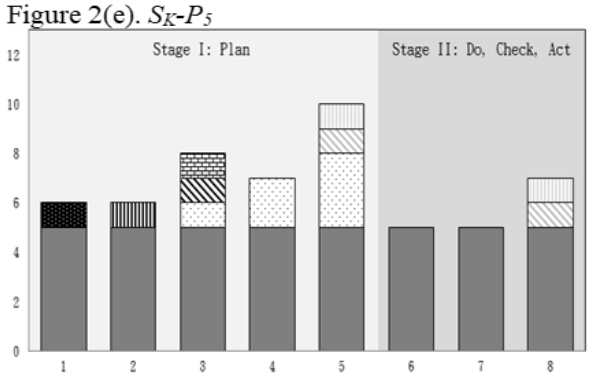

Figure 2(g). S_K-P_7

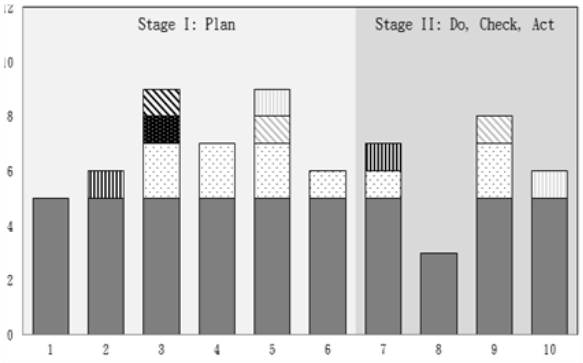

Figure 2(h). S_K-P_8

Figure 2. The instances of routines for S_N

5.2 Significance of routines to knowledge creation for S_N

Table 4 indicates the significance of routines to system measures. The p-value = 0.00 suggests that individual knowledge routines are significantly related to knowledge creation. The R2 is between 0.73 and 0.83 (more than 0.7), indicating a strong linear relationship between knowledge routines and knowledge creation. Meeting is revealed to be the most significant routine to TSM3 with |Coeff| = 2.56 and SSM2 with |Coeff| = 2.00. Gemba is the most significant routine to TSM1 with |Coeff| = 2.38 and TSM2 with |Coeff| = 2.97. Coaching is the most significant routine for SSM1 with |Coeff| = 2.38. Referencing is found to be consistently the least significant routine to most measurement items in all case studies.

5.3. Significance of routines to knowledge creation for S_K

Table 5 indicates the significance of routines to system measures. The p-value = 0.00 suggests that individual knowledge routines are significantly related to knowledge creation. R2 falls between 0.83 and 1.00 (more than 0.7), indicating a strong linear relationship between knowledge routines and knowledge creation. Meeting is the most significant routine to TSM1 with |Coeff| = 3.19, TSM3 with |Coeff| = 2.56 and SSM2 with |Coeff| = 2.69. In addition, Gemba is the most significant routine to TSM2 with |Coeff| = 3.50. Mentoring is most significant to SSM1 with |Coeff| = 2.86. Referencing is found to be consistently the least significant routine to most measurement items in all cases.

Table 4. Multiple regression results of routines to the system measures of knowledge creation for S_N

System	System measures	Multiple regression	Constant	Meeting	Gemba	Mentoring	Coaching	Referencing
S_N	TSM_1	|Coeff|	8.5	1.81	2.38*	1.84	2.00	0.72#
		p-value	0.00	0.00	0.00	0.00	0.00	0.00
		R^2	0.79					
	TSM_2	|Coeff|	8.50	1.88	2.97*	1.47	1.53	0.91#
		p-value	0.00	0.00	0.00	0.00	0.00	0.00
		R^2	0.83					
	TSM_3	|Coeff|	8.50	2.56*	2.16	1.72	1.69	0.63#
		p-value	0.00	0.00	0.00	0.00	0.00	0.00
		R^2	0.82					
	SSM_1	|Coeff|	8.50	1.03#	1.72	2.31	2.38*	1.31
		p-value	0.00	0.00	0.00	0.00	0.00	0.00
		R^2	0.79					
	SSM_2	|Coeff|	8.50	2.00*	1.84	1.41#	1.97	1.53
		p-value	0.00	0.00	0.00	0.00	0.00	0.00
		R^2	0.73					

Table 5. Multiple regression results of routines to the measurement items of Kaizen success for S_K

System	Measurement items of knowledge creation	Multiple regression	Constant	Meeting	Gemba	Mentoring	Coaching	Referencing
S_K	TSM_1	|Coeff|	8.50	3.19*	2.06	1.75	1.25	0.50#
		p-value	0.00	0.00	0.00	0.00	0.00	0.01
		R^2	0.91					
	TSM_2	|Coeff|	8.50	2.25	3.50*	1.38	1.13	0.50#
		p-value	0.00	0.00	0.00	0.00	0.00	0.00
		R^2	1.00					
	TSM_3	|Coeff|	8.50	2.56*	2.25	2.19	1.00	0.75#
		p-value	0.00	0.00	0.00	0.00	0.00	0.00
		R^2	0.85					
	SSM_1	|Coeff|	8.48	0.86#	1.17	2.86*	2.17	1.64
		p-value	0.00	0.00	0.00	0.00	0.00	0.00
		R^2	0.84					
	SSM_2	|Coeff|	8.50	2.69*	1.63	2.25	1.44	0.75#
		p-value	0.00	0.00	0.00	0.00	0.00	0.00
		R^2	0.83					

5.4. Comparison between S_N and S_K

The mean ratings of knowledge creation for S_N and S_K are 3.7 and 4.6, respectively. Knowledge actors moderately agreed that S_N improved knowledge creation and strongly agreed that S_K improved knowledge creation. Figure 3 plots the rating of knowledge creation, and Table 6 analyzes it. S_K achieved higher mean than S_N with 100% confidence level. Apparently, the implementation of S_K enhances the effectiveness of knowledge creation than S_N.

Table 6. t-test analysis for S_N and S_K

Hypothesis tested:		
H0: Mean rating in S_K < Mean rating n S_N		
H1: Mean rating in S_K > Mean rating in S_N		
	S_N	S_K
Mean	3.73	4.54
Standard deviation	0.47	0.25
Count	40	40
	p-value	0.00
Confidence that mean rating in S_K > mean rating in S_N		100%

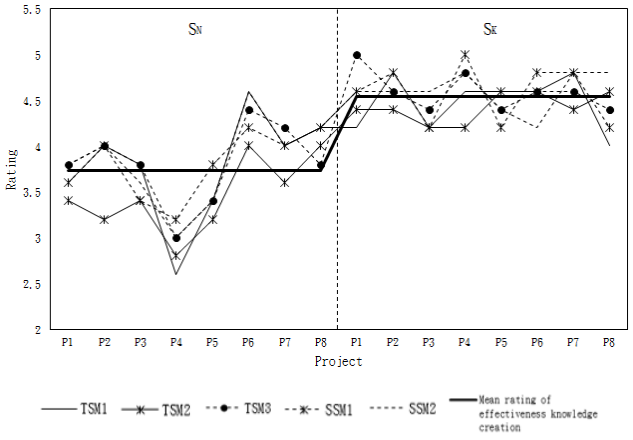

Figure 3. Comparison between S_N and S_K

6. Discussion

6.1. Comparison between S_N and S_K

The result shows the enhancement in S_K to produce effective knowledge creation. The enhancement provided a regime to enable an orderly extraction of high-quality knowledge through proper planning of routine phases. Hence, this process helps knowledge actors articulate and create knowledge to overcome obstacles during the Kaizen. Additionally, the enhancement induces the flow of SECI and shared space of Ba in routines. Mentoring is used in S_K as an illustrating example. The routine starts with a generative conversation between the leader and mentor (socialisation through originating Ba), collecting findings (externalisation through interacting Ba and combination through systemizing Ba) and reflective dialogue during tollgate (internalisation through exercising Ba).

S_N, on the other hand, was found relatively lax in the planning stage of the Kaizen. An example in S_N-P4 shows that the mentor discovered a false application of prioritisation matrix during the mentoring in Week 8. Specifically, the setting of priority number was determined without considering the customer's voice. This mistake in hindsight has resulted in the poor selection of root causes and therefore, countermeasures. This event potentially contributes to the failure of S_N-P4.

In S_K, the interactions between knowledge actors are regular. Interaction is particularly vital for sharing tacit knowledge [60][16]. Figure 4 shows the face-to-face interaction of the kick-off meeting of S_K-P_2 in Week 3. The kick-off meeting is instrumental to recognise the common interest among the Kaizen members. The presence of these interactions affirms that knowledge in Kaizen was created in applying the LSS procedural knowledge.

Figure 4. Event of kick-off meeting in S_K-P_2. Source: Author's photo archive.

S_K also attributes to a structured process in converting tacit and explicit knowledge and the forming of Ba correspondingly in S_K, hence preserving the dynamic nature of knowledge creation. Knowledge actors successfully anticipated what type of knowledge to be created, where, how (what interactions), and whom knowledge originated. The origin of knowledge is crucial to knowledge creation to warrant the validity of knowledge (e.g., right type of knowledge, processes, and actors) instead of deriving from others' perception and allegation. Verifying the origin of knowledge prevents incomplete, distorted, and partial knowledge creation [26],[61].

6.2. Significance of routines to knowledge creation

All routines in both systems show significant relationships to knowledge creation. Gemba is the most significant routine to knowledge creation in S_N, while meeting is the

most significant routine to knowledge creation in S_K. At another end of the spectrum, referencing is the least significant routine to knowledge creation for all case studies.

Meeting is the most significant routine to TSM1 in S_K. The routine is also the most significant to TSM3 and SSM2 in both sets of case studies. Meetings provide a setting for cross-functional knowledge actors to share knowledge and generate ideas. Activities related to the meetings were primarily conducted in a formal meeting room (originating Ba) with knowledge actors, and knowledge creation was manifested through socialisation such as interactions, practices, and communications. A high degree of autonomy allows knowledge actors to share relevant tacit knowledge and tune their knowledge parallel to the Kaizen goal. A kick-off meeting is useful for knowledge actors to continually improve and share tacit knowledge about the Kaizen. During the kick-off meeting, a briefing by the mentor and champion helped align the Kaizen success, knowledge vision, and business goals of the organisation and boosted the impact of TSM3. Meeting enhances SSM2 when knowledge actors are required to make informed decision, such as countermeasure selection. This process signifies indwelling of the LSS procedural knowledge, in the adoption of decision analysis and making tools. In the meeting, knowledge members expressed and discussed their tacit knowledge (ideas, opinions, and experiences) regarding the agenda. This process leads to improving their skills primarily to fulfil SSM2. It is exemplified through process virtualisation via flowcharting, brainstorming of root causes using a cause-and-effect diagram, and countermeasure selection through an effort-and-impact diagram.

We choose S_K-P_4 to illustrate the impact of a meeting to TSM1, TSM3, and SSM2. Among all Kaizens, S_K-P_4 has the highest frequency of meeting (15 frequencies including kick-off meeting) as shown in Figure 2(d). It is necessary because separate meetings must be organised at different stages with different departments to discuss the offload process. Activities related to meeting were primarily conducted in the proper meeting room with knowledge actors, where knowledge creation was manifested through the interactions, practices, and communications in the originating Ba. Knowledge actors expressed their ideas, opinions, and experiences regarding the process flow. Root causes were brainstormed among members using the cause-and-effect diagram through externalisation, while countermeasures were selected using the effort-and-impact diagram through combination. Upon the Kaizen completion, the experience of knowledge actors felt through convinces them of the significant influence of S_K to TSM1, TSM3, and SSM2.

Gemba in the case studies contribute to focused observation, conversation, and deliberation with personnel in the working area, focusing on operation performance. Gemba contributes to exercising Ba, where a right amount of conversation of tacit knowledge with key actors on the explicit knowledge in the field is crucial in developing mutual trust and acts as a ground to share knowledge. Gemba increases interactions of tacit knowledge with the process owner or other personnel in the working area, aiding in the early detection of mistakes or errors in applying procedural knowledge and reducing the problem's perceived complexity. Direct observation of people doing work internalised the tacit knowledge about processes or standards. The resultant knowledge, through combination, helps improve performance and maximise TSM2. S_N-P4, has the lowest frequency of Gemba as depicted in Figure 1(d). From the feedback, the knowledge leader of S_N-P4 often has a relatively short Gemba and seldom interacts with others during the Gemba trip. It limits interacting Ba and knowledge creation, eventually contributing to the Kaizen failure.

Coaching appears to be the most significant routine to SSM1 in S_N while mentoring the most significant routine to SSM1 in S_K. The champion played a more short-term role. The role of champion ended in conjunction with Kaizen completion. The coach, as observed in the case study, motivates the Kaizen leader to assimilate new learning by casting a wider perspective and association of Kaizen projects with other entities of the organisation. By contrast, the mentor helps build leadership character and cultivates LSS culture and attitude in knowledge actors, especially knowledge leader. A standard role assumed by the mentor in the case studies is to counsel the Kaizen team on the usage of Kaizen steps and LSS tools, not only for indwelling of knowledge but targeting perfection in problem-solving skill. This goal means that the mentor must pick up the conscious elements of the individual learning process and help the individual develop appropriate cognitive maps of these two domains. The role of mentor continues even after the Kaizen completion, thereby constituting a long-term role in comparison. A case in point can be drawn from an event of mentoring in S_K-P_2. Figure 6(a) shows the provision of tollgate between the Kaizen leader and mentor. The mentor examined and guided knowledge leaders to apply the correct LSS procedural knowledge in Kaizen. Figure 6(b) showed the provision of coaching between the knowledge leader and mentor. Dialogue was predominantly reflective and generative as the mentor used suitable examples including analogies to explain the concept and way forward in LSS thinking, strengthening procedural knowledge of the Kaizen leader. The learning effect is generally reciprocal as the mentor often reinforced and acquired a new level of understanding on relevant knowledge during mentoring.

Figure 6(a). Event of S_K-P_2 during mentoring (tollgate). Knowledge leader (female) was having a face-to-face discussion with mentor (male) in the meeting room. Source: Author's own photo archive.

Figure 6(b). Event of S_K-P_2 during mentoring. Mentor provided examples of LSS procedural knowledge and wrote them on the whiteboard for common understanding. Source: Author's own photo archive.

Referencing is found to be the least significant routine consistent to most measurement items in all systems. The contributing factor could be inadequacy of reference materials in organisational knowledge repository and skills in analyzing, reflecting, and synthesizing knowledge from the found reference material. Nevertheless, whenever suitable reference material is obtained, the information is always fully maximised by knowledge actors and hence significantly enhances knowledge creation.

7. Conclusion

This study enhanced the five Kaizen routines to improve knowledge creation and later compared them in 16 equally divided case studies. The result found that routines in S_K induced better knowledge creation than S_N, individually and collectively. Between routines, meeting and Gemba were the most significant to knowledge creation, and referencing was the least. This research benefits both academics and practitioners. It contributes novelty to routines and knowledge creation, contextualised through the Kaizen case studies. Insights gained from the study add research values to fields, such as knowledge creation, knowledge management, and organisational learning, among others. As for practical implications, the research findings prompt practitioners in LSS to seriously consider routines and their task-specific variants in organisation undertakings not limited to Kaizen, to improve knowledge creation, utilisation of knowledge, and ultimately problem-solving strength. As regards limitations, the case studies were carried out in a lean organisation which already institutionalises its Kaizen process, including the team structure, coordination, regulation, and reporting mechanisms. The discussion of knowledge creation is made only at individual and group levels.

Future research could incorporate different mainstream knowledge theories into the proposed routine systems, expanding the concept in-depth and breadth. An example would be the empirical studies on the relationship between Kaizen routines and five enabling conditions of knowledge creation. Then, another dimension in [32]'s knowledge creation model pertains to knowledge assets, apart from the SECI and Ba which are already included in this research. The role of leadership could be considered as it has undergone various discussions in literature to facilitate knowledge creation. As for research limitations, the current research focused on implementing routines and knowledge creation in Kaizen for low management level. Routines and knowledge creation would differ at higher management levels such as Hoshin Kanri. Additionally, this research is based on a single manufacturing organisation. The results obtained may vary in other types of organisations.

8. Acknowledgements

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