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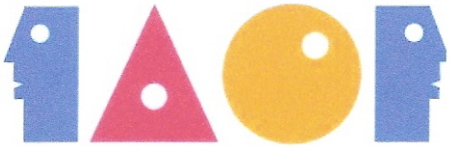

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CLOUD SERVICE BASED QUALITY CONTROL CIRCLE

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Abstract

Quality control circle (QCC) has been implemented worldwide for many years with substantially positive results and acclaim in various domains. However, situations such as employee business trips, absences, and schedule conflicts have decreased the attendance rates of QCC activities. Paper-based meeting records have not only limited QCC members' access but also hindered energy conservation and carbon reduction efforts. To address these problems, this study applies cloud computing to QCC activities. Specifically, the U-Office Force software is employed to implement cloud-based QCC activities in a small business through the plan–do–check–action method. The results reveal that the introduction of cloud service increases the attendance rate of QCC members regardless of their location, improves the access to data, reduces paper consumption, enhances managers' monitoring of the progress of QCC activities, and enables employees to clearly understand of the operation and procedure of QCC activities.

Keywords: Management, Quality Control Circle, Cloud Service, PDCA

Introduction

Quality Control Circle (QCC) activities are performed by frontline members on-site to address the quality issues within an organization. In addition, these activities involve using creativity, self-reflection, and mutual inspiration to enhance quality control (QC) ideas and practices. To improve QCC activities in organizations by increasing the attendance rate of QCC member discussions and enhancing the efficiency of searching for data and accessing records, this study implemented a cloud computing system through the U-Office Force (UOF) software developed by e-Excellence. The cloud software enables convenient online QCC activities and discussions that are not hampered by distance. Even if employees are away from the office, QCC activities can still be held as usual, because discussions can be conducted anytime, with the relevant records, documents, and data stored in the cloud. As employees can access all these data at their convenience, the cloud service truly facilitates the synergy of mutual learning between employees and the organization as a whole.

Literature Review

Numerous studies have researched QCC activities. Juran (1967) claimed that QCC groups consist of departmental work leaders and line operators who voluntarily spend time in meetings and discussion outside of their work hours. Rieker (1985) claimed that QCC is the heart of a quality program that is constituted of voluntary members of normal organizational work crews and their supervisors. Peters (1987) proposed that once QCC members develop their team work abilities, QCC leaders should empower team members with decision-making rights, lest the excessive reliance on leaders limit the effect of QCC activities on organizational performance. Robbins (1988) stressed that QCC inspires employee awareness and a sense of responsibility through its plan–do–check–act (PDCA) method of group activities based on practical needs, which creates a more favorable working environment and improves work quality. Steckler and Fondas (1996) argued that QCC leaders act as the link between the team and external units because they share information outside of the QCC with team members to solve problems within the circle. Kwong (2000) asserted that a QCC consists of employees who proactively solve production problems by combining group wisdom and QC practices. Salahedin and Zain (2007) indicated that QCC teams can analyze problems, identify their causes, generate alternative solutions, and eventually implement the most adequate ones. In addition, there is a need to empirically test and refine the critical factors affecting the successful implementation of QCCs. Prasanna and Desai (2011) noted that the implementation of QCC identifies deficiencies caused by staff, material, method, and machine, and facilitates resolving each deficiency and proposing overall corrective measures. Kitazawa and Osada (2012) statistically analyzed the tangible and intangible effects of QCC on the basis of the management style of QCC. Generally, the factors for tangible effects were the setting of the financial amounts and improvement rate, whereas the factors for intangible effects were the setting of organizational capabilities developed by QCC. Oko and Udensi (2013) argued that (a) QCC is an informal organization within a company, (b) the implementation of QCC activities is often hampered by cross-departmental

communication problems, and (c) problems with corporate policies and product quality must be alleviated through enhancing internal communication and personnel training. Chengfei et al. (2014) maintained that the approach of QCC management empowers nurses with sense of responsibility in the management process, effectively tapping the potential of nursing management to achieve full participation of the nurses in quality management and enhancing their added value. Veeraselvam (2014) stated that a QCC is a relatively autonomous unit that holds regular meetings of employees to discuss work-related problems, but that QCC members cannot plan their participation with a short notice. Anand Jayakumar & Krishnara (2015) argued that organizations must develop a team-based environment to enable grassroots employees to actively participate in QCC activities. This can improve productivity; process efficiency; and employee skills, confidence, and creativity through cumulative processes of education, training, and work experience. Sha, Hsu, and Chen (2016) stressed that to improve the conventional QC process; creative problem solving can be adopted in a QCC through systematic and logical procedures. The aforementioned literature thus reveals that under the rapid changes in the current global environment, QCC activities are beneficial to organizations, but that QCC members' participation and contribution is required for QCC activities to be effective and sustainable. Therefore, a cloud computing implementation of QCC should be beneficial.

Mell and Grance (2010) listed three service and four deployment models of cloud computing, which the National Institute of Standards and Technology of the United States considers a model for enabling convenient and on-demand network access to a shared pool of configurable computing resources. Marston et al. (2011) asserted that cloud computing requires a clear understanding of the various issues involved, both from the perspectives of the providers and the consumers of the technology, but that the effects of these issues vary by stakeholder. Xu (2012) stated that two types of cloud computing adoptions in the manufacturing sector have been implemented: manufacturing with direct adoption of cloud computing technologies, and cloud manufacturing (i.e., the manufacturing version of cloud computing). The direct adoption of cloud computing has enabled the manufacturing sector to flexibly customize customer solutions, whereas in cloud manufacturing, customers can request cloud services addressing product design, manufacture, testing, management, and all other stages of a product's life cycle. Although cloud computing may produce various benefits for organizations, more careful assessment and planning is required before implementation. To provide small and medium enterprises with a cost-effective cloud service, the present study employed the UOF cloud computing software developed by e-Excellence as shown in Figure 1.

QCC activities contribute immensely to various industries, but cannot easily integrate employees from different sites. Cloud services mitigate geographical limitations by providing employees with a platform for mutual learning. Employees without relevant expertise might not be able to operate cloud computing with ease, but UOF developed by e-Excellence provides a user-friendly platform for everyone. Therefore, this study integrated QCC

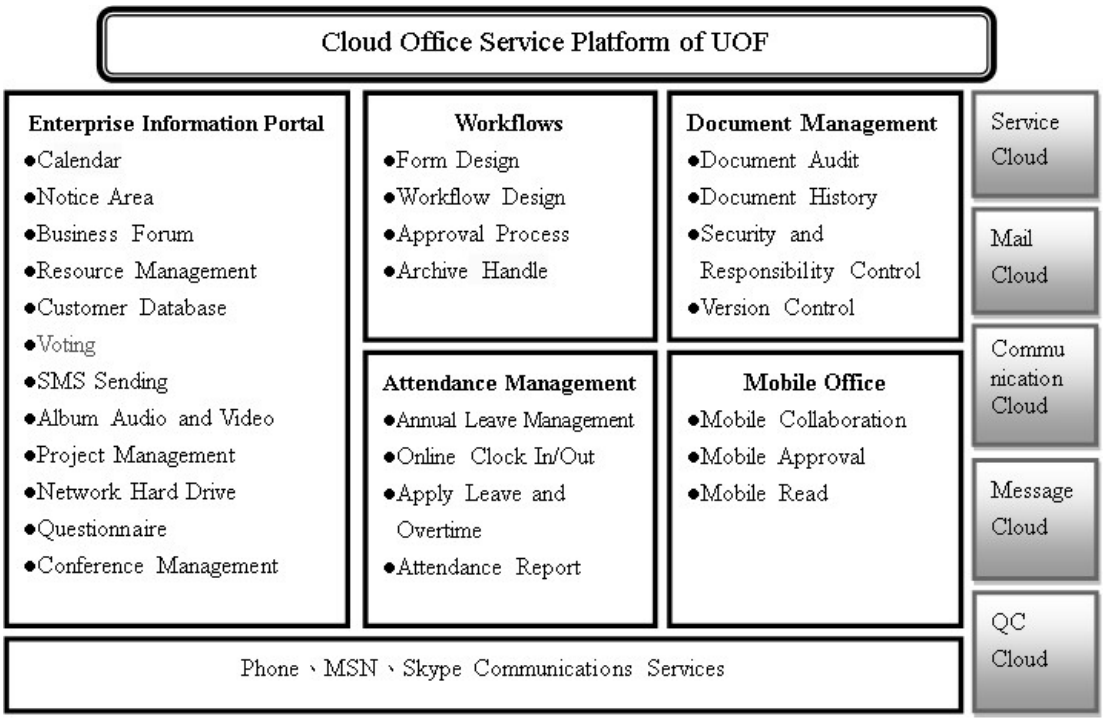


Figure 1. Platform of UOF (Source: e-Excellence)

activities and cloud computing to provide organizations with a feasible, user-friendly solution.

Methodology

This study employed a problem-solving orientation to identify problems. After the discussion and implementation stages between QCC members, the discussion results were published and standardized to facilitate the identification and recognition of QCC.

QCC activities

The QCC activities in this study are based on the PDCA method. QCC activities were first introduced to gain recognition and support from senior executives within the organization because without internal recognition, QCC activities are often impeded by implementation challenges and low employee participation. After this initial introduction, QCC leaders spontaneously organized QCC groups consisting of 8–10 members each to mitigate work-related problems through various QC methods.

The implementation process of the first QCC was comprehensively rendered in the cloud platform to facilitate other employees' understanding of PDCA operations. The QCC members held meetings on the cloud platform, with detailed meeting records archived for on-demand review. After the completion of the first QCC project, the company published announcements in the cloud platform to encourage other employees to become involved in the QCCs. Once all QCC teams had begun their activities and proposed various projects for organizational improvement, the projects were transferred over the cloud platform to the QCC headquarters for approval. After the completion of each project, the headquarters published the procedures and result of each project

in the cloud platform to keep employees informed.

Figure 2 illustrates the cloud-based QCC integrated and implemented using UOF. The various services provided by UOF enable easily access to the results of cloud-based QCC for employees.

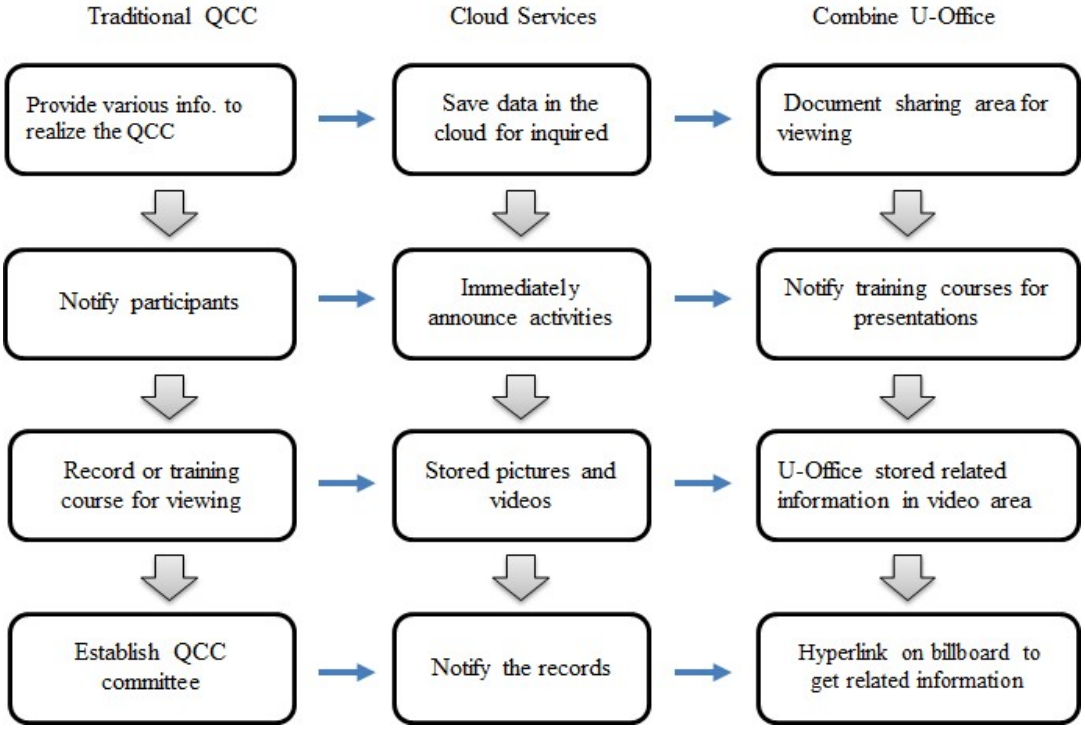


Figure 2. Cloud-based QCC integrated through UOF

Cloud-based QCC

Cloud-based QCCs employ the PDCA method, in which plan involves the process of concept-generating and planning, do denotes the implementation of the proposal after approval, check entails the discussion and improvement after problems are discovered during the implementation, and action is the overall promotion of the proposal, followed by the iteration of new PDCA cycles after the proposal is completely implemented and problems solved.

➢Plan
- ●Schedule and announce meeting in the conference room.
- ●Upload data related to the meeting to the DMS for managers to understand QCC operations.
- ●Upload reviews of QCC lessons to the forum.
- ●Share pictures of various proposals and collaborations in the album.
- ●Announce establishment of the QCC headquarters and promotion committee after preparations are completed.

➢Do
- ●Schedule QCC training courses and upload to Meetings.
- ●Upload training material to the DMS for open access.
- ●Design and upload training feedback surveys to Questionnaires.
- ●Upload announcements and regulations to the DMS.

- Start a Q and A thread on the forum to encourage QCC members to express their opinions anonymously.
- Upload the results to the Announcement, Forum, and DMS.

➢Check
- Add an administrators-only section in the forum for administrators to discuss and confirm others' problems and challenges.
- Conduct a survey of QCC activities in Questionnaires after implementation.
- Schedule meetings to address problems, challenges, and survey results in Meeting.

➢Action
- Standardize the discussed results.
- Archive various topics discussed in the forum.

This study integrated the theories and empirical applications of the aforementioned procedures of cloud-based QCCs, and verified the related concepts through a case study.

Case Study

The subject of the case study was a screw manufacturer, which is a small and medium enterprise, in Kaohsiung, Taiwan. As a small and medium enterprise in Taiwan, the company was established in 1986 with a registered capital of NT$ 25 million, several certifications from the International Organization for Standardization, and approximately 125 employees. The screw factory featured numerous machines to accommodate orders for a wide range of screw styles (i.e., multiple blows and dies). Because of the large number of orders and the need for QC before shipment, the company installed several precision instruments for quality inspection.

PDCA of cloud-based QCC

The PDCA cycle of cloud-based QCC introduced to the factory is described as follows.

➢Plan
- Theme selection
  i) The demand for quality in various industries has increased, and subsequently the QC challenges faced by contractors have also increased. Therefore, measures such as QCC are required to improve QC.
  ii) Cloud services can be conveniently applied to various industries. Employees can participate in discussions regardless of location, and cloud services provide convenient documentation and access of discussion records.
- Objective selection
  i) Organization-centric: Cloud services improve corporate image and internal communication. Manufacturers always demand quality. As quality improves, organizations gain numerous benefits. Cloud services have become increasingly ubiquitous in recent years because of technological advances in business environments.
  ii) Employee-centric: Employees strive for an excellent working environment and salary. The QCC implementation effectively improves the work environment and provides employees with opportunities for bonus compensation. Cloud services can conveniently record meeting information and provide employees with an additional communication platform. Such services also enable veteran

employees to share their experiences and new employees to provide novel ideas.

- Goal setting

  Goals: Incorporate cloud services to QCCs and improve the operational environment of QCCs.

  Reasons:

  i) Improve production quality and profitability.

  ii) Promote employee collaboration and increase employee income.

- Problems and countermeasures

  i) Managerial level: A lack of interpreters to explain how QCC operates, low short-term profits from QCC, a high investment cost of cloud service equipment, and a lack of understanding of the benefits of cloud services.

  ii) Employee level: Increased working hours, detailed benefits not explained, long waiting times for approval, and a lack of understanding of how QCC operates.

  iii) Workplace environment: Employee schedule conflicts, struggles for older employees to understand cloud services, and no reference data within the company.

➢ Do

- Countermeasures for managerial concerns

  i) Invite cloud service and QCC professionals to provide trainings at the company.

  ii) Provide information concerning QCC activities.

  iii) Invite high-ranked officials to precipitate in competition events related to QCC.

  iv) Rent cloud service equipment instead of purchasing it.

- Countermeasures for employee concerns

  i) Elect a QCC task force within the company for counseling.

  ii) Implement a bonus system for exemplary QCC activity.

  iii) Implement a paperless approval system through cloud services.

- Countermeasures for environmental concerns

  i) Provide reference books for cloud services and QCC activities.

  ii) Introduce cloud services through guest speeches.

  iii) Encourage employees familiar with cloud services to explain related operations to their colleagues, and to conduct discussions with others.

  iv) Schedule and carry out discussion sessions in the cloud platform.

➢ Check

- Determine whether employees at all levels within the company understand cloud services and operation of QCC activities. Subsequently, carry out the first QCC activity, which enhances the harmony among segments of the factory, thus enabling factory operation to be smooth and efficient.
- Set the ultimate goal and related regulations during QCC activities. During the PDCA cycle, improve interdepartmental harmony within the factory for an improved flow of operations in the factory.

➢ Action

The cloud-based QCCs resulted in improved data access, meeting attendance, quality improvement, and documentation compared to before they were introduced. During the PDCA process, cohesiveness between departments in the factory was improved, facilitating factory operations.

QCC applications of UOF

This study carried out the cloud service through UOF. Figures 3 through 9 display screenshots of the UOF portal where users can clearly access functions including Document, Album, Meeting, Announcement, Forum, and Approval. These indices link to the corresponding functions for data access, internal discussion, and document signing and approval.

Case Study of Cloud-Based QCC

After the introduction of QCC, the QCC groups underwent related training and executed relevant operations. The selected issue to be addressed by the groups was as follows: Insufficient diameters of screw threads caused by improper machine configuration. The results of implementing QCC to resolve this issue are discussed in the following sections. Figure 10 depicts the screw threads and points of the case study.

➢Plan

●Theme selection

Most screw manufacturers produce in high volumes with little variety. If improper configuration cannot be identified or specific threads and points cannot be produced during the production process, substantial losses can be incurred by the company. Therefore, when screw factories accept orders with only slightly divergent specifications, the probability of error increases. A specification inspection and maintenance of production machinery may be necessary at the beginning of the production phase with subsequent reviews for every 1000 screws produced.

●Objective selection

i) Production-centric: Reduce the defect rate. Once the quality guaranteed by the screw company can be improved, the production cost is effectively reduced. Because production machinery is prone to damage from long-term usage, multiple inspections of the equipment can reduce the incidence of errors. Therefore, the objective of the QCC activity was "to reduce the defect rate by conducting additional production inspections."

ii) Client-centric: Clients demand complete goods and accurate delivery times, and products with higher completeness result in greater benefits to the screw company. Because accurate delivery times can reduce inventory costs, production inspections ensure clients' trust in manufacturers' productivity.

●Goal setting

i) Goals: Reduce the production errors caused by wear and tear or improper configuration of machinery.

ii) Reasons: To improve production quality, reduce wear and tear, and enhance the factory's reputation.

●Problems and countermeasures

i) People: inadequate follow-ups by employees, employees responsible to follow up on too many production lines, and employee input errors.

ii) Machines: Wear and tear, inadequate maintenance, and loose input parameters.

iii) Environment: Excessively long production lines, excessive number of orders, and difficulties

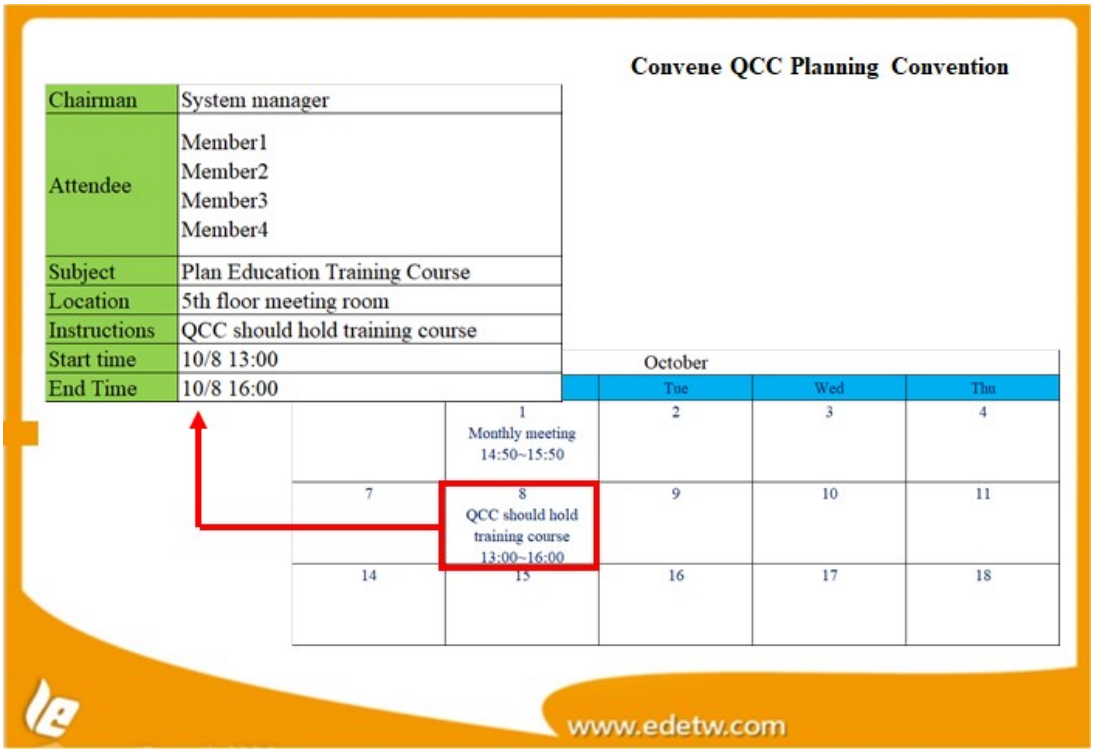


Figure 3. Cloud-based QCC Activity 1

Figure 4. Cloud-based QCC Activity 2

Figure 5. Cloud-based QCC Activity 3

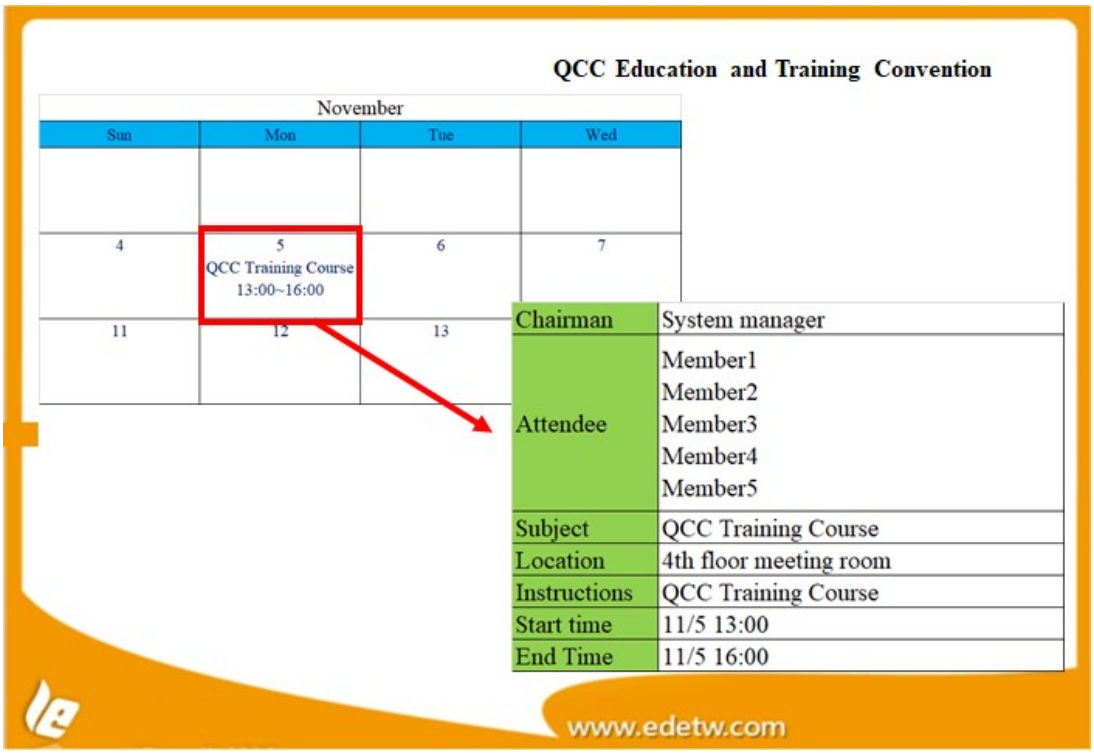


Figure 6. Cloud-based QCC Activity 4

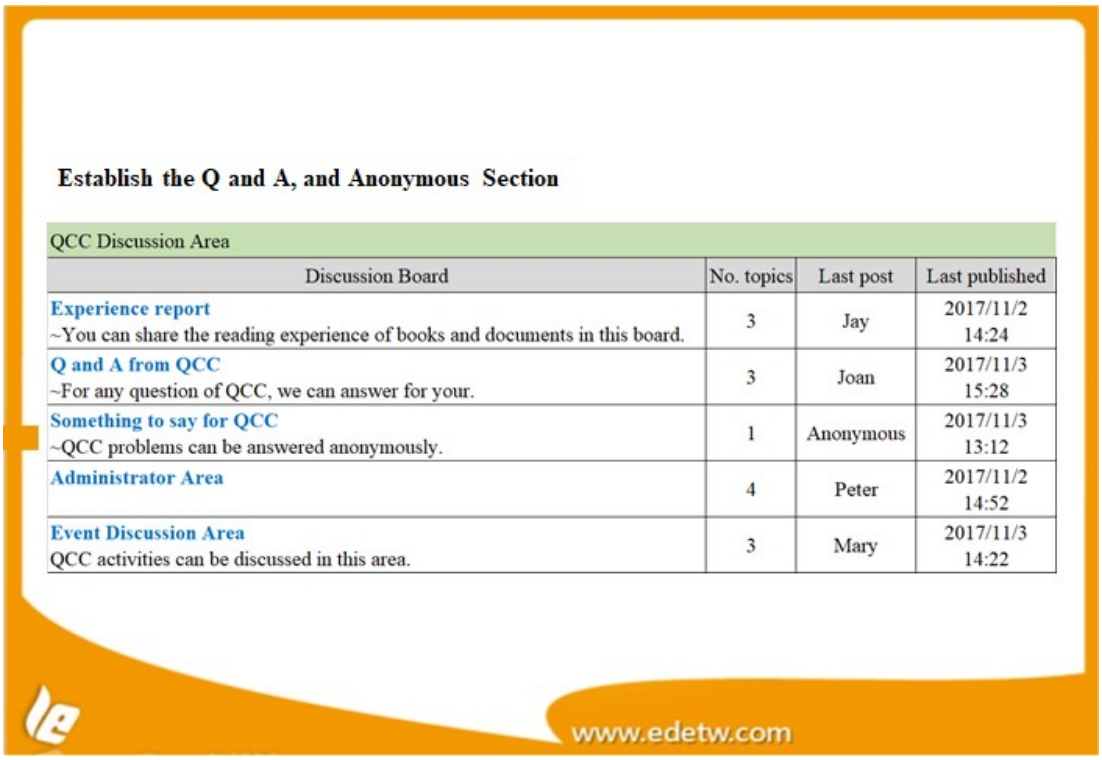


Figure 7. Cloud-based QCC Activity 5

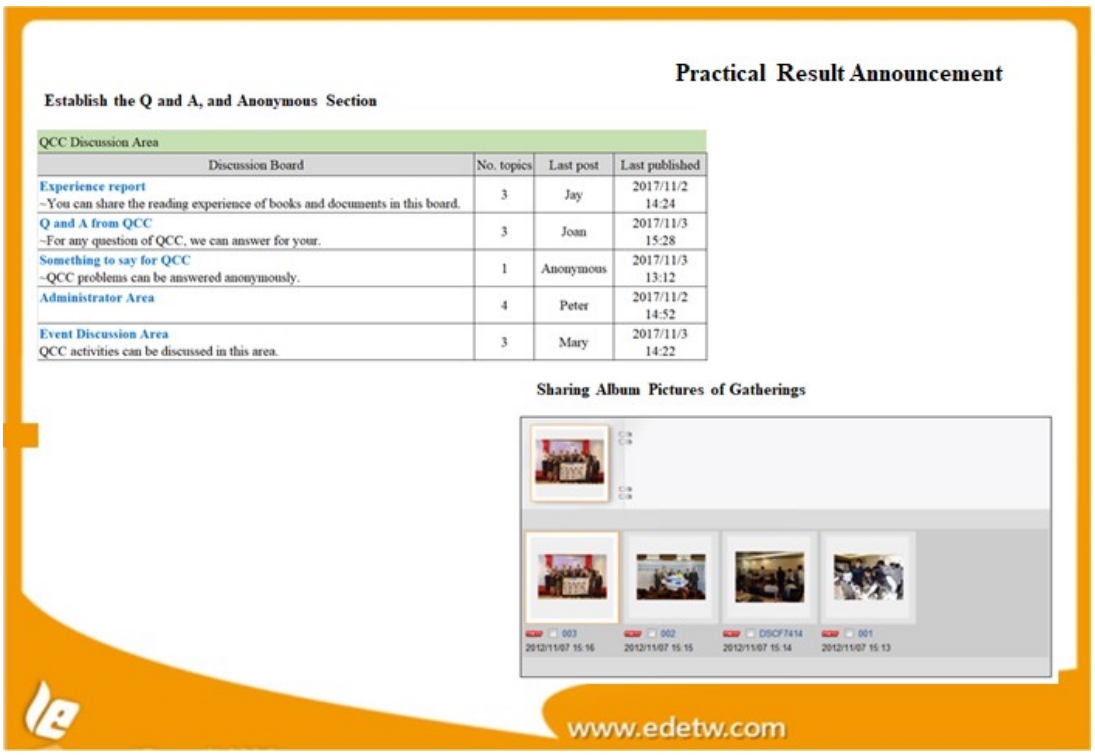


Figure 8. Cloud-based QCC Activity 6

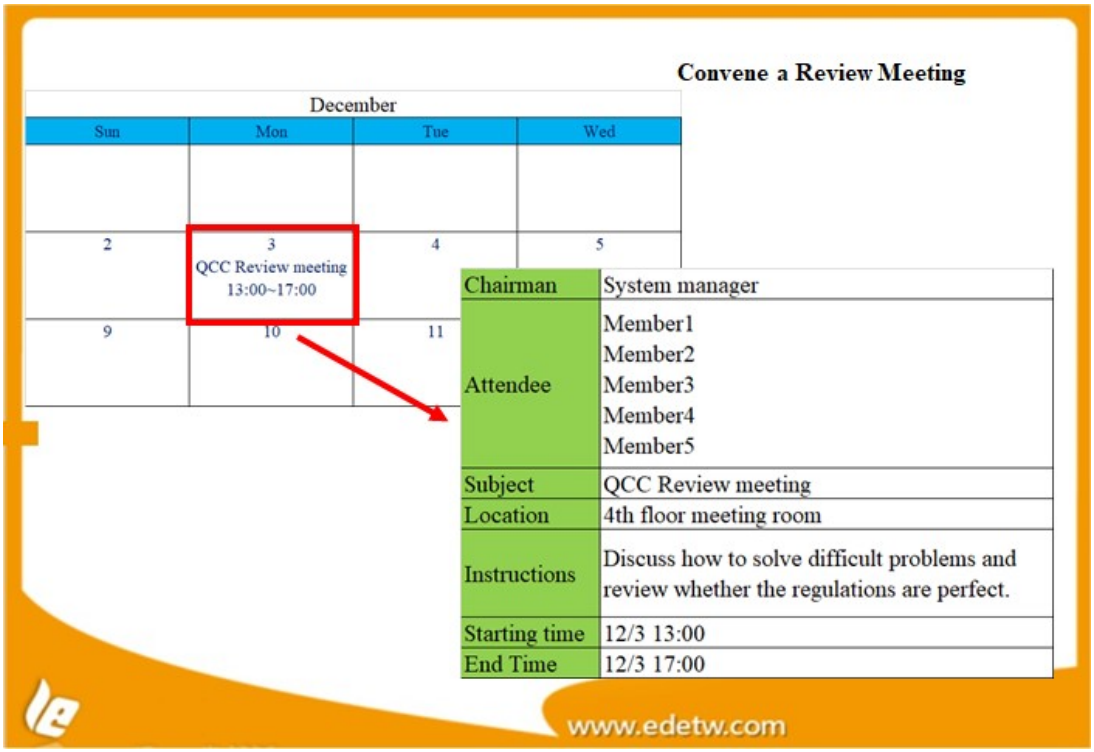


Figure 9. Cloud-based QCC Activity 7

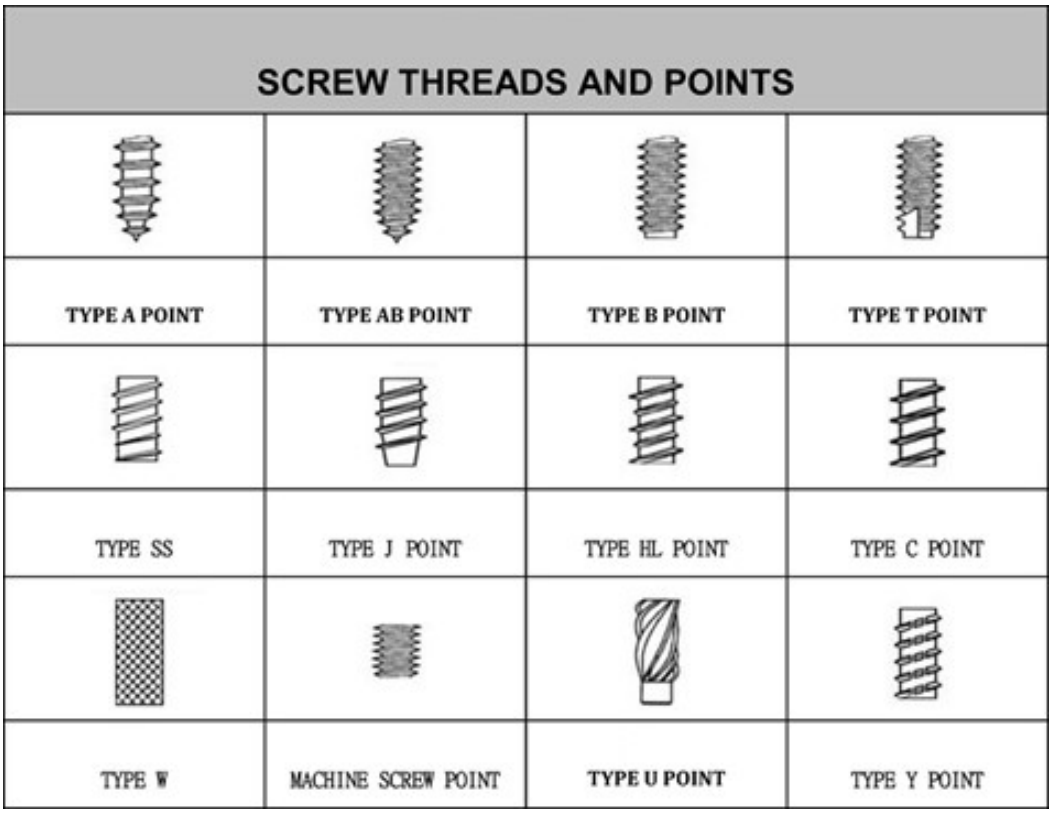


Figure 10. Screw threads and point

halting production.
iv) Time: Tight schedules caused by excessive orders.

➢Do
- Countermeasures for human factors
  i) Increase the number of employees following up on the production lines: Because the production lines go through numerous steps, the probability of error increases if employees are responsible for following up on a substantial amount of steps. Increasing the number of employees may reduce production errors.
  ii) Avoid assigning employees to follow up on the same type of models: Employees were prone to production errors when asked to follow up on the same type of model. Assigning employees to follow up on distinct model types may substantially reduce such errors.
  iii) Additional auditors: After employees input the inspection data, additional auditors may substantially reduce input errors.
- Countermeasures for machine factors
  i) Machinery maintenance before the production process: Long maintenance cycles may lead to the wear and tear of parts. Scheduling brief maintenance before the production process may alleviate this problem.
  ii) Rigorous specifications for input: Machine wear and tear may not be immediately identified if the input data were too loose, leading to excessive deviations from screw specifications.
- Countermeasures for environmental factors
  i) Handle similar orders separately: Scheduling the production of the same type of order at the same time increases product stock quantity and results in inventory errors.
  ii) Produce with multiple production lines to reduce downtime.
- Countermeasures for time factors
  i) Production scheduling and order management: More orders translate to higher profits, but rushed orders lower the quality of goods. Therefore, effective production scheduling and order management may increase production quality.

➢Check
- Tangible results: Improved product quality reduced the defect rate and enhanced the company's image.
- Intangible results: Employees who participated in the cloud-based QCC understood the PDCA method, improved team cohesiveness, acquired a sense of accomplishment, and improved their cross-departmental communication skills.

➢Action

Table 1 compares the production conditions before and after the improvement measures were adopted to alleviate the issue of insufficient screw thread diameters, demonstrating that improved product quality reduced the defect rate of the goods. Furthermore, accurate delivery times decreased the production, shipping, and inventory costs.

Figures 11 through 14 illustrate how QCC members discussed the identified problems and solutions on UOF After cloud-based QCC was implemented in the factory, standardized and detailed regulations and procedures were generated for other employees' reference, as shown in Figure 15.

Table 1. Production conditions before and after the improvement measures

Before improvement	After improvement
Employees inputted wrong data	An additional auditor was engaged to ensure the accuracy of input data
Employees were responsible for too many production lines	Multiple employee shifts were implemented for effective production line monitoring
Machine wear and tear varied by raw material	An increased number of employees for production inspections enabled immediate identification of machine malfunctions and damage, as well as immediate repairs or data reconfiguration
Errors were not identified until product completion	
Rescheduled production could not meet deadlines	

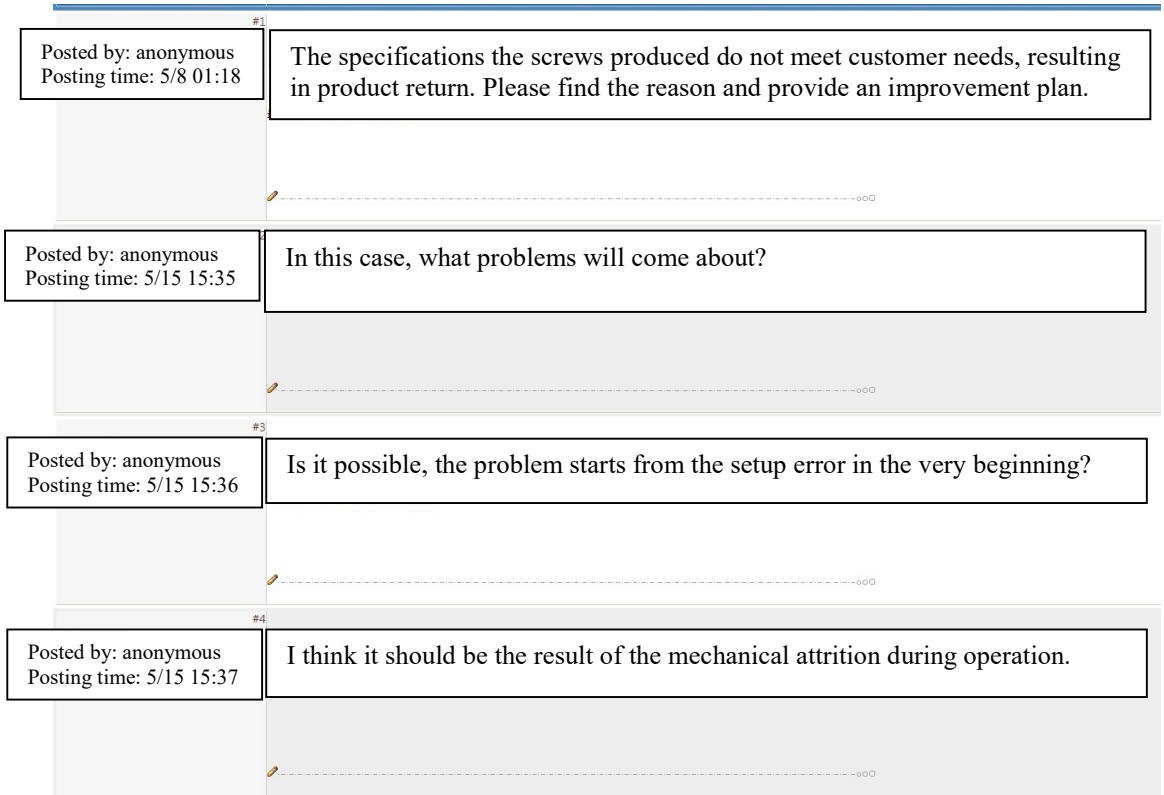


Figure 11. Online discussion on UOF (1)

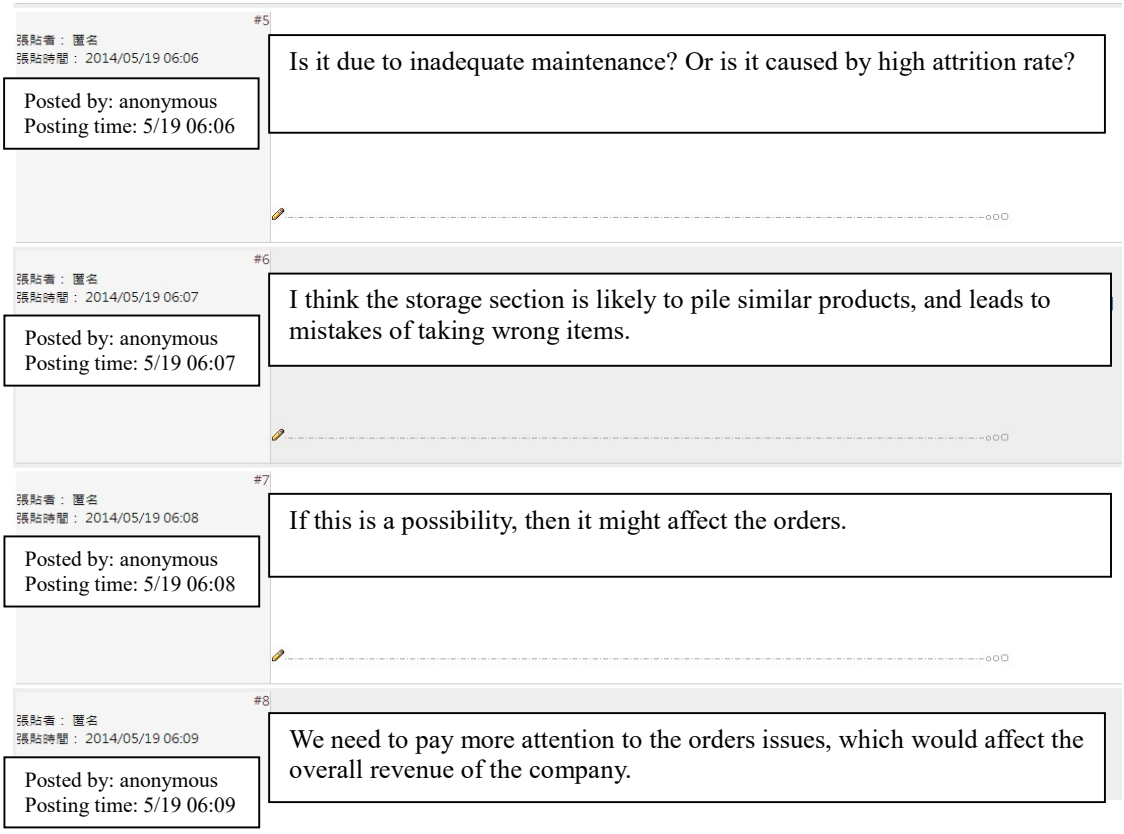


Figure 12. Online discussion on UOF (2)

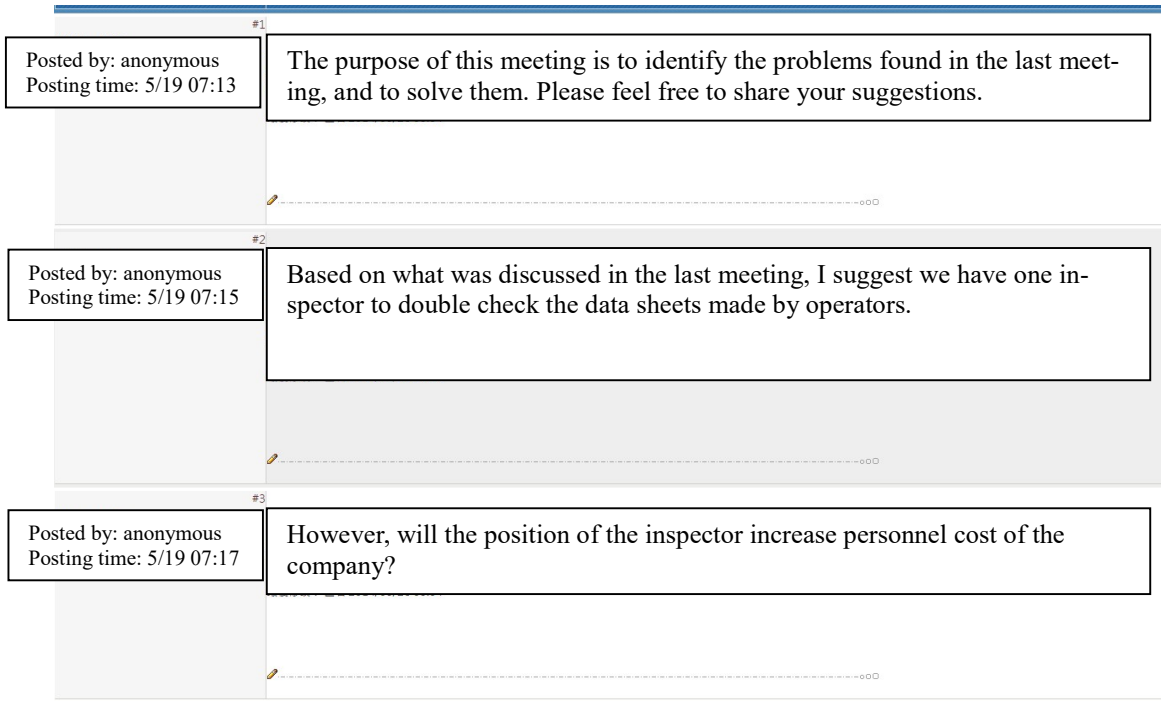


Figure 13. Online discussion on UOF (3)

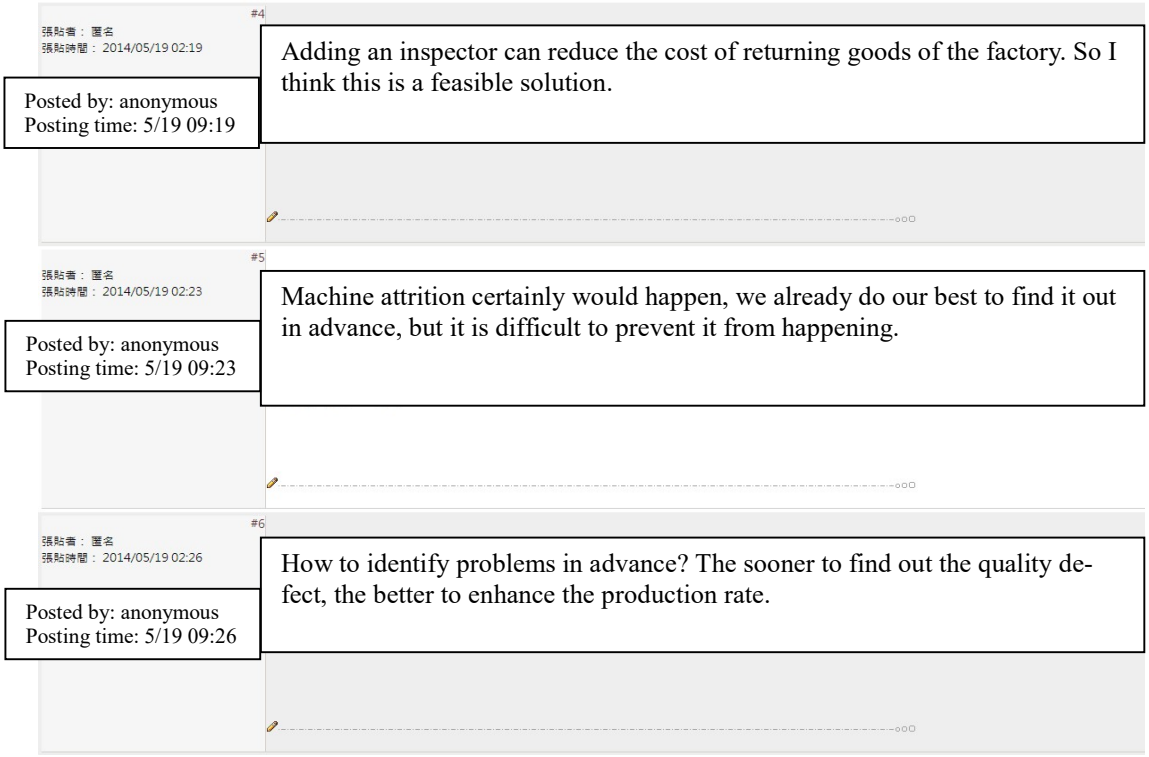
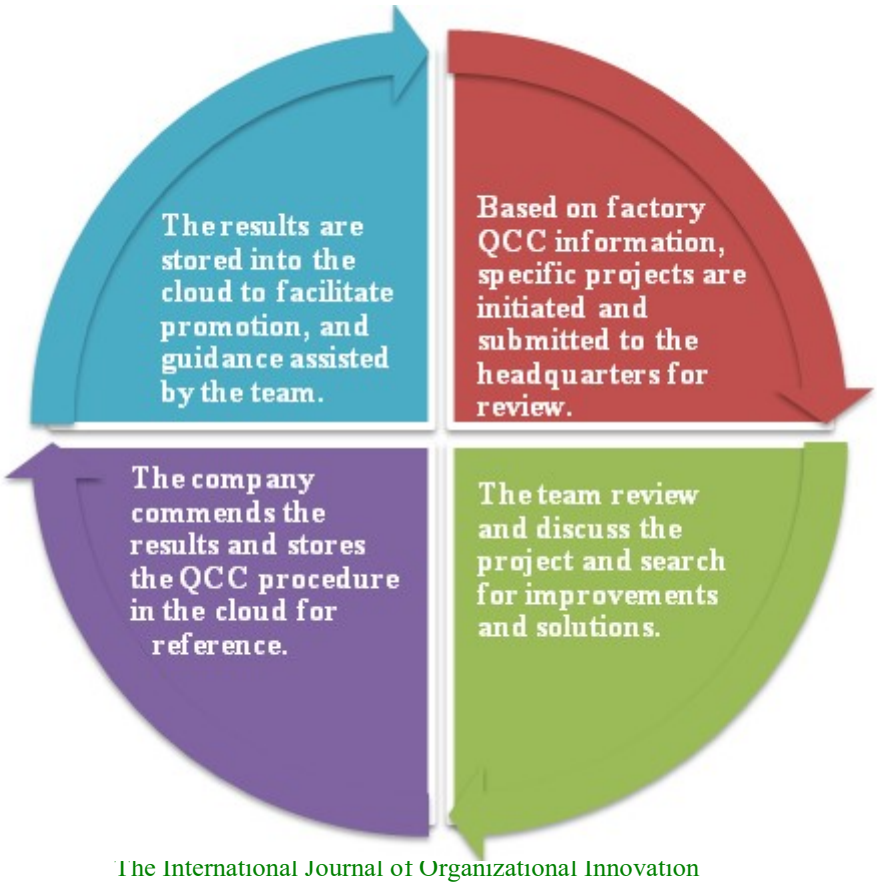


Figure 14. Online discussion of UOF (4)

Figure 15. QCC cycle after the cloud service was introduced.



QCC online discussion on UOF

Subsequently, the employees actively identified production-related problems after they obtained QC- related knowledge through corporate assistance. Consequently, employees throughout the factory began to consider how to improve production quality. After the QC methods were standardized, collaborations between employees transformed the factory into a large-scale QCC, resulting in mutual learning and encouragement between employees.

Conclusion and Suggestion

This study examined cloud computing for QCC activities in a screw-manufacturing factory. The proposed system not only improved the attendance rate of QCC members but also simplified the documentation of QCC meetings. Furthermore, the ubiquitous cloud service improved data access. The UOF software enabled convenient QCC operation by storing meeting records, documents, and data within the cloud. In addition, the cloud-based discussions allowed the remote participation of employees who were away on business trips. The QCC members had convenient access to all data stored in the cloud, which accomplished mutual learning and employee synergy. Furthermore, cloud-based QCC exhibited other benefits, including an efficient data transfer process, effective scheduling of cloud-based meetings, paperless data archiving, the ability to comment anytime on the cloud platform, increased mutual learning between employees, and improved understandings of QCC operations and procedures.

Employers in small and medium enterprises could potentially benefit from cloud-based QCC. However, such enterprises usually have an inadequate number of employees for long-term operation of QCC activities, which require mutual learning and growth between multiple QCC groups. In addition, the enterprises do not generally use cloud services for daily operations, impeding the implementation of cloud-based QCC. Therefore, future studies should examine how to facilitate collaboration between small and medium enterprises and cloud service providers for cloud-based QCC to be beneficial to both entities.

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