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Improving group problem solving through awareness of members' problem-solving preferences

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Abstract

Purpose – Many groups in organisations are unsuccessful in problem solving. However, the principle of continuous improvement necessitates that organisations refine their employees' problem-solving skills. In this mixed-method, field-based lab experiment, we explored the impact of a treatment to enhance the quality of group problem-solving processes.

Design/methodology/approach – We focused on the structured problem-solving process in Kaizen Events by differentiating six consecutive phases. About 16 Kaizen Event groups (101 members) participated in a field-based lab experiment that used a lean simulation game to establish a group problem-solving context. Data were collected via video, surveys and group interviews. We examined if a high-quality process is strengthened through group members' elevated awareness of problem-solving preferences. About 11 groups received a treatment of tailor-made individual feedback to increase awareness of their problem-solving preferences. Additionally, we repeated the experiment in five control groups, where member preferences were not shared.

Findings – In the treatment groups, where problem-solving preferences had been shared, we observed a clear improvement in Kaizen Event process quality and higher problem-solving self-efficacy levels. Moreover, their self-reported Kaizen Event behaviour had changed. Within the control groups, the participants also reported that their problem-solving self-efficacy had improved, but this did not have a positive impact on the quality of the objectively measured Kaizen Event process.

Originality/value – By combining insights from operations management and organisational behaviour, we demonstrate that the structured Kaizen Event problem-solving process improves when group members' individual problem-solving preferences are shared. We thus add an individual-level variable to the extant models of Kaizen Event success factors. Our results provide fresh insights into how to improve the continuous improvement process within organisations. Kaizen Event stakeholders and their facilitators are offered guidance on how to increase one's awareness of own and others' problem-solving preferences in group-based problem-solving events.

Keywords Group problem solving, Problem-solving preferences awareness, Process improvement, Kaizen Event, Field-based lab experiment

Paper type Research paper

1. Introduction

Improving processes requires addressing (often persistent) organisational problems in such a way that the perceived problem can be understood and resolved (Hicks, 1991; Kepner and Tregoe, 1965). Hence, enhancing an operational process is not only simply a theoretical exercise to determine the best possible solution but also concerns the "invention" and sustainable implementation of a new standard practice and ensuring that employees know how and agree to execute them. The goal and final result of those improvement initiatives must be that an organisation's operational performance is improved (Franken *et al.*, 2024; Netland and Ferdows, 2016). Given that organisations face so many challenges that need adequate responses, the process of effective problem solving contributes to their desired dynamic capabilities (Dieste *et al.*, 2022).

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Within operations management (OM), dynamic capabilities development levels are seen to relate to the competitive advantage of an organisation (Bititci *et al.*, 2011; Singh *et al.*, 2018), such as through the development of continuous improvement skills (Anand *et al.*, 2009; Gutierrez-Gutierrez and Antony, 2020). A basic continuous improvement skill is the capability of teams (and their members) to improve processes and to solve persistent problems (Hasan and Micheli, 2023; Mohaghegh and Größler, 2022). Since team performance arises from the knowledge and behaviour of group members (Kozlowski and Ilgen, 2006; Mathieu *et al.*, 2006), understanding individual behaviours during problem-solving events and improving the effectiveness of the problem-solving process will enrich the problem-solving theory that is increasingly prominent in OM (Furlan *et al.*, 2019; Mohaghegh and Größler, 2022; Negrão *et al.*, 2016; Wieland and Durach, 2021).

To realise process improvements, many organisations form problem-solving groups, as they are known to be more effective in solving complex problems (Hackman and Morris, 1975; Kozlowski and Ilgen, 2006; Shaw, 1932). Those problem-solving groups are generally composed of individuals with the expected expertise to solve the problem (Bendor and Page, 2019; Stapleton, 2007). External management consultants often guide this problem-solving process (Netland, 2016; Pierce *et al.*, 2000). However, with the growing importance of the "21st century skills" set, in which complex problem solving is listed as one of the most important (Koehorst *et al.*, 2021), organisations are increasingly expected to invest in the problem-solving skills of their own employees (Flynn *et al.*, 2010). Whenever the members of problem-solving groups are capable of executing a problem-solving process on their own, they can work independently, without additional external resources and grow in process improvement maturity (Netland, 2016), thereby improving the organisation's improvement capability (Hasan and Micheli, 2023; Jørgensen *et al.*, 2006).

However, many organisations struggle to implement effective problem-solving projects (Arellano *et al.*, 2021; Bortolotti *et al.*, 2015; Sousa *et al.*, 2014). One of the reasons is that organisations do not problematise or take the quality of the group problem-solving process seriously (Flynn *et al.*, 2010). Consequently, improvement initiatives fail in many organisations (Antony and Gupta, 2019). Thus, both practitioners and scholars alike need a better understanding of group behavioural processes to attain high operational problem-solving capabilities and achieve improved operational performance (Allen and Lehmann-Willenbrock, 2023).

The quality of a problem-solving process is defined as the extent to which the process fits its purpose, that is, the extent to which the problem is (partly) solved and that it will not re-occur (Franken *et al.*, 2021). Regarding structured problem-solving approaches, which are widely seen as being most effective for sustainable solutions (Mohaghegh and Furlan, 2020), groups have to follow a phased process in an orderly manner (Hicks, 1991; Liker, 2004; Woods, 2000). Furthermore, we know that group processes emerge bottom up from group members' behaviours and interactions, whereby those processes are influenced by individual group member's knowledge, skills, self-efficacy as well as work preferences or habits (Bandura, 1982; Hirsh *et al.*, 1992; Kozlowski, 2015). Although we realise that all aspects of an organisation's culture, like structure and leadership, are part of the environment in which problem-solving groups craft process improvement (Van Dun and Wilderom, 2016; Wageman *et al.*, 2005), we assume in the current study that engaging in a high-quality group problem-solving process is a key factor for effective operational problem solving (Flynn *et al.*, 2010; Franken *et al.*, 2021). We focus herein on individuals' contributions to the group problem-solving process because individuals' problem-solving preferences in relation to group problem-solving process quality have hardly been explored and seem to matter for organisational success (Farris *et al.*, 2009; Netland, 2016).

Whilst empirically exploring the role of those individual preferences in the quality and outcome of group-based complex problem-solving processes, we focused on the structured problem-solving approach inherent in a Kaizen Event (KE). Kaizen is a Japanese term meaning "improve for the better", which is a key value within Lean's continuous improvement

philosophy (Liker, 2004). A KE is a processual approach to solving complex problems (Womack and Jones, 1996) and is defined as "a focused and structured continuous improvement project, using a dedicated cross-functional group to address a targeted work area, to achieve specific goals in an accelerated timeframe" (Farris *et al*., 2009, p. 42). KEs are performed by cross-functional groups brought together to solve a complex operational problem. Given the task, the functionally most appropriate employees are tasked to solve a problem without considering the extant structures already in place. KE groups are expected to attain success by following a fairly standardised approach (Mohaghegh and Furlan, 2020). Well executed KEs do not only result in social outcomes ("we learnt") but also in operational performance improvement ("problem solved") (Farris *et al*., 2009). A lot of scholarly literature is available on KEs and its antecedents for success (Bortolotti *et al*., 2015; Farris *et al*., 2009; Liu *et al*., 2015; Netland, 2016). However, research on how to improve the KE process itself is scarce and needed (Aleu and Van Aken, 2016; Hasan and Micheli, 2023). Better knowledge of how to achieve KE process quality will support our practical and theoretical understanding and will, in turn, lead to effective work-process improvement. Hence, this study is guided by the question: *How does group members' awareness of their own and peers' individual problem-solving preferences affect their group's problem-solving process quality in Kaizen Events?*

Below, we first delineate relevant theoretical frameworks for KE process quality and problem-solving preferences in group-based problem-solving settings. Then, in Section 3, we depict the field-based lab experiment, mixed-methods research design, including our intervention to raise problem-solving preference awareness, followed by the Results in Section 4. In the Discussion, Section 5, we sketch the theoretical and practical implications of the findings and offer a research agenda to, ultimately, improve organisations' improvement processes.

2. Theory

2.1 KE process quality

A KE is a structured problem-solving approach with predefined consecutive phases (Farris *et al*., 2009; Liker, 2004). In this study, we adopted a KE approach consisting of six phases: (1) Problem definition (PD), (2) Root-cause analysis (RA), (3) Generate ideas (GI), (4) Plan implementation (PI), (5) Implement (I) and (6) Check and sustain (CS) (Franken *et al*., 2021; Woods, 2000). Each phase has a specific goal and should bring about a specific result that is accepted by all group members. Only then will the group process move to its next phase (Hicks, 1991; Liker, 2004). To achieve the required result in each phase, specific member behaviours should be exposed. See Figure 1, columns 1 and 2.

KE process quality is regarded to be high when a process has been executed perfectly, meaning that a KE group follows those six sequential phases in an orderly manner, without skipping phases or "jumping" over phases (Dittrich *et al*., 2016; Franken *et al*., 2021; Hagemann and Kluge, 2017). Franken *et al*. (2021) offer a norm and measure for KE process quality, which is defined as the extent to which the observed KE process differs from the ideal KE process.

However, in reality, without any process guidance, KE groups tend to criss-cross through the different phases, resulting in a low-quality problem-solving process with the risk that the problem at hand will not be resolved (Carnerud *et al*., 2018; Franken *et al*., 2021; Suárez-Barraza *et al*., 2021). One of the causes of such a failure may stem from individual group members' differing problem-solving preferences; one member might prefer to start brainstorming immediately, others may keep questioning whether there is actually a problem, whereas some may jump into the details of it (Liu and McLeod, 2014; Puccio, 1999). Hence, sticking to the ideal KE process implies that some individual problem-solving preference will neither dominate nor be neglected in the KE process, because that would reduce the quality of the entire process and, most likely, also of the outcome.

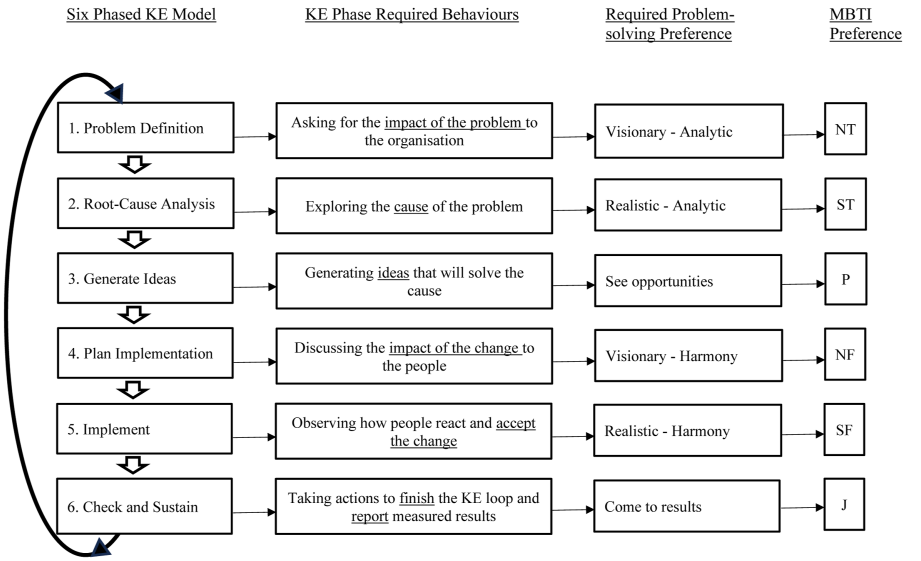

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Figure 1. KE phases (column 1), required behaviours (column 2), problem-solving preferences (column 3) and related MBTI preference (column 4) for each phase

To achieve the required KE process quality, the process should be orderly, and each KE phase has to deliver a specific result (Woods, 2000). To achieve each phase result effectively, a KE group has to show phase-related, problem-solving behaviour or, to be more specific, ask and answer the questions needed to achieve a phase's result (Liker, 2004; Woods, 2000). In KE phase 1, Problem definition, the impact of the problem on the organisation needs to be specified. This phase requires a visionary perspective, as the future impact has to be discussed as well as an analytic and fact-based approach because, in this phase, the indicator measuring the problem has to be set (Kepner and Tregoe, 1965; Liker, 2004). In KE phase 2, Root-cause analysis, the focus is on the current real-life situation. The perspective should still be fact-based (analytic), as the causes relate to the focal problem and its indicator(s) (Kepner and Tregoe, 1965; Liker, 2004; MacDuffie, 1997). To enact KE phase 3, Idea generation, the KE participants have to show behaviours which express seeing the opportunities (Johnson and D'Lauro, 2018; Lee and Farh, 2019). KE phase 4, Plan implementation, is about discussing how to realise a situation in which employees work collaboratively according to the chosen solution within an improved process. This phase not only requires a future perspective but also a perspective in which commitment to change and resistance are dealt with. So, the required problem-solving behaviour is visionary and focused on harmony (Bortolotti *et al.*, 2015; Hirsh *et al.*, 1992). In KE phase 5, Implement, the selected solution is implemented. The role of KE group members is to support employees as they accept and adapt to the implemented solution. This requires a focus on the current situation (realistic) as well as a consideration of the reactions and well-being of the employees, with the aim of fostering harmony (Fenner *et al.*, 2023; Hirsh *et al.*, 1992). In KE phase 6, Check and sustain, a KE loop is finished and its results are measured. Hence, the focus of the phase should be on reporting the measured results (Liu and McLeod, 2014). In Figure 1, column 3, we offer an overview of the required phase-related problem-solving behaviours that ought to dominate each phase (column 4 is explained in Section 3.3). Giving room to people with a behavioural pattern matching each phase is assumed to contribute to the quality of that part of the problem-solving process. Therefore, in

the empirical part of this study, we explore if members' awareness of their own and other group members' problem-solving behavioural preferences relate to the quality of the group problem-solving process.

2.2 Individuals' problem-solving preferences

What do we already know about how individuals differ in approaching problem-solving tasks? The Swiss psychologist Carl Jung described psychological types based on the fundamental differences in individuals' personalities which lead to different behaviours (Jung *et al*., 1964). He referred to a person's preference as a preferred way to perform a task, which, in turn, becomes visible in one's behaviour, e.g. by asking questions from a specific perspective (Hirsh *et al*., 1992). For example, an individual with a future-oriented focus will ask questions related to the impact of a problem, whilst an individual who focuses on the current situation prefers to ask questions about why the problem has occurred (Hirsh *et al*., 1992). On the other hand, group members focusing on generating even more new ideas may forget about finishing the KE loop (Puccio, 1999). Thus, an individual's problem-solving preferences concern ones inherent tendencies and preferences in terms of gathering information, analysing data, generating ideas, making decisions and implementing solutions (Hirsh *et al*., 1992). Those differences between group members' preferences do affect group processes, including a group's problem-solving effectiveness (Mathieu *et al*., 2017; Stone, 2010; Woods, 2000).

Given that group processes emerge from group members' interactions (Kozlowski, 2015), the group's approach to a problem-solving task should occur naturally, bolstered by each member's self-efficacy to expose and use personal preferences and capabilities (Bandura, 1982; Kozlowski and Ilgen, 2006). To give an example, when starting up, some group members might suggest following an orderly approach, whereas others may reject this suggestion, as they prefer to "go with the flow" (Liu and McLeod, 2014). This may lead to group quarrels on how to approach the task, even before starting. One reason for such discussions in any KE phase can be attributed to individual differences in problem-solving preferences (Hirsh *et al*., 1992; Liu and McLeod, 2014).

Although preference differences might lead to group discussions, arguments, or even conflicts, previous research has shown that teams composed of members with heterogeneous preferences achieve better quality processes than homogeneous teams (Mathieu *et al*., 2017; Stapleton, 2007). Jung's theory suggests that individuals, despite having a preference style, can also use a non-preferred style when required and when they are willing to do so, especially when it is evidently necessary to accomplish the group's task (Buffinton *et al*., 2002; Hirsh *et al*., 1992; Jung *et al*., 1964).

Because the quality of a KE's process is influenced by the extent to which prototypical phase questions are asked and answered (see Figure 1, column 2), and because specific problem-solving behaviour is required per phase (see Figure 1, column 3), individuals with particular work preferences fitting a KE phase will naturally support the KE process's quality by asking those questions at the beginning of their preferred phase (Hirsh *et al*., 1992). Moreover, when specific problem-solving preferences are missing in a KE group, there is a risk that not all the core questions that need to be answered will be addressed, i.e. if they are not aware of this missing preference. So, for a group to be effective in a problem-solving process, the challenge is to use the diversity of the available members' problem-solving preferences as effectively as possible to improve the quality of the problem-solving process. This leads to the practice-relevant question: How can we ensure that KE group members use each other's preferences to attain an optimal problem-solving process?

2.3 The importance of problem-solving preference awareness in KE events

Awareness pertains to an individual's state of mind upon becoming conscious of something (Zeman, 2006). When individuals are self-aware of their skills and have the (self-)efficacy to use them, they can decide pro-actively to apply these skills for themselves or in groups (Black

et al., 2019; Caldwell and Hayes, 2016; Zeman, 2006). Self-efficacy is important in the development of task strategies, e.g. in the selection of a preferred process approach to solve a problem (Bandura, 1982; Judge *et al*., 2007).

An individual's problem-solving preferences and aligned problem-solving behaviour can contribute to the group problem-solving process, but only if an individual has enough self-efficacy to use this skill (Bandura, 1982; Judge *et al*., 2007). Sometimes, individuals do not dare to speak up, and important questions that they could raise remain unanswered (Edmondson, 1999). As a result, a value-adding dialogue can be missed or even KE phases might be skipped, resulting in lowered KE process quality (Franken *et al*., 2021).

During a KE, the group is responsible for solving a problem (Farris *et al*., 2009). To be effective, it is important that a group trusts its members' skills and collective knowledge necessary to accomplish this complex task (Katz-Navon and Erez, 2005; Monteiro and Vieira, 2016). However, as the group is brought together for a specific task and its members may be (almost) strangers at the start, the time needed to develop such group trust is limited (Santos *et al*., 2015). We assumed here that sharing knowledge and information about each group member's preference, by adding it to the group's shared mental model, can be considered a strength or group asset during the KE phases and may aid a KE group to perform well (Katz-Navon and Erez, 2005; Lim and Klein, 2006; Liu *et al*., 2015; Mathieu *et al*., 2017).

An invitation to use one's problem-solving preferences can come from the other group members, or it can also be brought to the table by explicit process requirements. For example, in project management, project leaders are expected to keep an eye on the timeline since it is likely that they want to deliver the results on time (Besteiro *et al*., 2015). Although it may be hard for group members to follow this process requirement, no one will contend with it, as all members know that this is a necessity of the project management process itself (Liu and Cross, 2016). Following this reasoning and based on the KE phases and on answering each phase question adequately (Figure 1, column 2), it can be argued that the KE process "invites" group members to use their specific preferences and aligned skillsets when "their" KE phase comes up. Of course, accepting such a process invitation should be safe for many KE group members without risking group-member judgement (Edmondson, 1999). For that to happen, the whole group has to know about the process needs, and this should be part of a group's shared mental model (Carraro *et al*., 2024; Fenner *et al*., 2023; Lim and Klein, 2006). This means the group should be aware of the preference needs of each phase in the KE process (Figure 1, column 3). When all members know and are aware of the problem-solving preferences and associated skills of each group member, they must combine this knowledge to improve the quality of their KE group process. Effective KEs need the members to follow this intricate group interaction in an ideal behavioural manner. However, this does not often occur naturally in KE groups. Hence, a specific intervention was designed to aid these groups.

We envisioned that, when a KE group receives feedback on the quality of the performed problem-solving process, including each individual's contribution, it will lead to learning and capability development (Shute, 2008; Van den Bossche *et al*., 2011). This, in turn, can lead to enhanced problem-solving skills and increased individual and group efficacy in problem-solving endeavours (Bandura, 1982; Edmondson, 1999; Hackman and Morris, 1975). On that basis, we designed an intervention whereby group members are made aware of their own as well as the other group members' problem-solving preferences, aimed at improving KE process quality. In what follows, we depict the nature of this intervention by using mixed-methods to examine its group behavioural effects.

3. Method

3.1 Research design

A field-based lab experiment was designed to examine the effects of an intervention in KE groups to improve their group problem-solving process quality. The aim was to capture as much of the participants' natural problem-solving behaviour as possible (Coppock and Green,

2015). Since simulation games can provide an enhanced learning experience (Kuriger *et al*., 2010; Pasin and Giroux, 2011), we used one to create a setting where participants could become aware of their (ineffective) group problem-solving process and experience the impact of sharing problem-solving preferences on the quality of the group process. We organised on-site workshops using the lean simulation game "@dministration", a game frequently used by Dutch lean consultants. In this game, participants must work together to improve non-working production processes. A further description of this simulation game is presented in Appendix 2. In this three-hour simulation game, the groups had to execute three production rounds, alternated with two improvement rounds and an intervention after production round 2.

During the intervention, the treatment groups received the tailor-made feedback to increase awareness of their problem-solving preferences related to the required KE phase behaviour. After sharing those insights, participants discussed and shared their experiences. Instead, the control groups discussed the production problems observed in the game and if they also recognized those problems in their daily work. Table 1 offers an overview of the workshop agenda and the treatment and control interventions.

A two-wave, mixed-method approach was employed on all the groups, with video observations of the KE groups' problem-solving processes as they went through the simulation game; surveys among the individual KE participants and, finally, KE group interviews. One week before the simulation workshop, at Time 1 (T1), the participants filled out a questionnaire. At Time 2 (T2), the actual three-hour workshop took place.

3.2 Operationalisation of problem-solving preferences

To be able to connect the required behaviour in each KE phase to human behaviours, we turned to Jung's theory of human behaviour (Jung *et al*., 1964). In his seminal theory, Jung explained how individuals tend to differ in their behaviours. This theory also explains how individuals

Table 1. Agenda of the workshop at T2: treatment and control groups

Estimated time in minutes	Treatment groups	Control groups
15	1. Welcome, kick-off and instruction - Introduction to KE structured problem solving - Instruction rules simulation game	1. Welcome, kick-off and instruction - Introduction to KE structured problem solving - Instruction rules simulation game
15	2. Simulation round 1	2. Simulation round 1
15	3. Improvement round 1 (videotaped)	3. Improvement round 1 (videotaped)
15	4. Simulation round 2	4. Simulation round 2
15	Break	Break
30	5. Instruction to problem-solving preferences in KE - Explanation of KE circle and preferences - Map individual preferences on flipover Reflection: recognition of behaviour	5. Group discussion impediments in the process Questions: - Which problems in the simulation game influenced performance? - Can you think of a comparable situation in your daily job?
15	6. Improvement round 2 (videotaped)	6. Improvement round 2 (videotaped)
15	7. Simulation round 3	7. Simulation round 3
15	8. Individual survey T2	8. Individual survey T2
15	9. Group interview (videotaped)	9. Group interview (videotaped)
15	10. Closing of the workshop	10. Closing of the workshop
Total: 180 min		

Source(s): Created by authors

with similar preferences tend to exhibit similar behaviours and approach tasks in a similar manner, whilst individuals with different preferences tend to behave differently (Hirsh *et al*., 1992; Jung *et al*., 1964). Based on this theory, four areas of behavioural differences can be distinguished, namely: (1) how one retrieves energy, with a preference for extraversion (E) or introversion (I); (2) one's mode of taking in information, through using one's senses (S), based on reality, or by being more visionary through making use of intuition (N); (3) one's way of making decisions, either based on analytic thinking (T) or on a more harmony-based feeling (F) and (4) one's way of organising day-to-day life, with preferences for judging (J) and then following a plan to achieve results or being open to perceiving (P) opportunities (Hirsh *et al*., 1992). For example, individuals with a preference for extroversion tend to be talkative and are energised by working in groups, whereas individuals with introversion tendencies are more reflective and are energised by moments of quiet and solitude.

To determine the KE participants' problem-solving preferences, we used the MBTI instrument. While the MBTI instrument itself has been critiqued for its explanatory value (Stein and Swan, 2019) and reduced validity and reliability due to misuse of the instrument (Capraro and Capraro, 2002; Coe, 1992; Pittenger, 2005; Randall *et al*., 2017), it is still used widely in practice as a means to increase people's awareness of their own personal preference styles at work (Gardner and Martinko, 1996; Stapleton, 2007). Since one of this study's aims was to emphasise awareness of each individual's problem-solving preference, we selected the MBTI instrument for our study, especially given that scholars tend to agree that it is valuable for creating awareness about personal preferences (Randall *et al*., 2017; Sedlock, 2005). We also ensured that the instrument was used correctly by following the MBTI manual (Myers-Briggs-Company, 2024; Myers Briggs *et al*., 1998) and that all the group members received their profiles from a certified MBTI trainer. First, the participants filled out a validated questionnaire (88 items). Second, the certified MBTI trainer explained the differences between the four behavioural dichotomies noted above so that the participants could estimate their own preferred type. Third, the participants received the survey feedback and, guided by the MBTI trainer, combined this feedback to determine their personal best fit type. This MBTI best fit type, summarised with a four-letter mnemonic, e.g. ENTJ or ESFP, was used for the present study.

Based on the required KE phase problem-solving behaviours depicted by extant literature (Woods, 2000) and the individuals' preferred behaviours based on the MBTI dichotomies (Hirsh *et al*., 1992), we associated each KE phase with one ideal MBTI problem-solving preference (Figure 1, column 4). During a group's problem-solving process, one's mode of taking in information (S/N) does seem to matter. Individuals with an S preference tend to focus on the current situation (e.g. during the Root-cause analysis and Plan implementation KE phases), whilst individuals with an N preference focus on the future situation (e.g. during the Problem definition and Plan implementation KE phases). One's decision-making method (T/F) also plays a role. When it comes to prioritising or decision-making, individuals with a T preference are task oriented and look at facts and figures (which is relevant during the Problem definition and Root-cause analysis KE phases), whilst individuals with a F preference will focus on well-being and harmony in the group (which is particularly important in the Plan implementation and Implement KE phases). Finally, when it comes to one's way of organising oneself (J/P), individuals with a J preference like to finish a task (especially useful in the Check and sustain KE phase), whilst individuals with a P preference tend to be creative and open to new ideas (e.g. during the Generate ideas KE phase). The dichotomy of retrieving energy, extroversion versus introversion, does not seem to be distinctive in KE required behaviours (Hirsh *et al*., 1992).

Given these associations, one can explain to individuals which KE phases match their MBTI type best or, as we named it, explain personal problem-solving preferences, which we did with the KE participants.

3.3 Simulation game as the context for the group intervention

To be able to observe all the phases in the KE processes across the 16 participating groups, each group took part in a simulated operational setting (Badurdeen *et al*., 2010; Pasin and Giroux, 2011), namely in the @dministration game (see Appendix 2).

At the start of the game, the first author explained the six phases of the KE process to each group and stressed that adhering to this structured process helps in being effective (see Table 1). Before the second improvement round, the intervention took place. The 11 treatment groups' participants were made aware of their own and the other group members' problem-solving preferences, related to the six KE phases. We drew the KE phases model as a circle on one flipchart, explained the KE phases and the required behaviours for effective problem solving and mapped all the groups' participants' problem-solving preferences on it. Then we asked the participants to reflect on those new insights based on their experiences during the first improvement round. This flipchart with the personalised group members' problem-solving preferences remained visible during the second improvement round. The intervention slides can be found in Franken (2024, pp. 177–181).

The five control groups' participants were asked about the issues they had observed during the simulation, and if and how those problems (or similar ones) were also visible in their own daily work. As the control groups' participants knew each other, they were able to discuss these points elaborately. At the end of each workshop, a semi-structured group interview was held, to reflect on the group's problem-solving processes and the individuals' and group problem-solving behaviours.

3.4 Sampling and sample description

The KE groups were selected through purposive sampling (Etikan *et al*., 2016). Each group had to consist of a minimum of four and a maximum of eight participants. The KE treatment groups were selected based on the following criteria: (1) the members had to already know their personal MBTI type and (2) each had to include at least three out of the four different MBTI functional types to create a setting in which behavioural differences can occur. To join a control group, no conditions were set. All 16 invited groups, selected through the first and second authors' lean networks, participated (Table 2).

The participants were individually invited by mail, in which they were also asked for their consent to be videotaped. The groups came from different organisations in different sectors; eight participating groups were familiar with the KE problem-solving approach: five of them used it in their consultancy work (group #3, #6, #8, #14 and #15) and the approach was used in three of the groups' organisations (group #9, #11 and #12). Three groups consisted of individuals who did not know each other before the workshop (strangers), five groups were colleagues, but did not work in the same work team, and eight groups were existing work teams. All the participants were highly educated (University trained: 66; University of applied sciences: 31; Vocational school: 4). Nearly all the groups were Dutch; 12 of the 101 participants had a foreign background. Workshops #4, 7, 10 and 16 were performed in English, the others in Dutch. Table 2 also shows the spread of the treatment group participants' MBTI preferences related to the KE phase preferences.

3.5 Data collection

Both one week before (T1) and at the end of the workshop (T2), a survey was distributed among all the KE-group members to collect the participant's self-perceived behaviour in each of the KE phases and their self-efficacy in problem solving. Self-reported problem-solving behaviour was measured with a new scale, consisting of 32 items on six subscales, with four to six items per KE phase (see Appendix 1). The items dealt with the required type of behaviour within each KE phase, e.g. "In a KE, I ask questions about the impact of the problem". As this questionnaire was newly developed, we first tested the sub-scales on the pre-required conditions to apply exploratory factor analysis (using SPSS; Bartlett's test <0.001 for all

Table 2. Characteristics of the participating teams

Group	Nr. of participants (M/F)	Type of organisation	Size of organisation	Knowledge of KE approach	Type of group	Number of participants with a matching KE phase preference (Figure 1) PD: NT	RA: ST	GI: P	PI: NF	I: SF	CS: J
Treatment groups											
1	6 (2/4)	n.a	n.a	No	Strangers	1	2	3	1	1	3
2	4 (0/4)	n.a	n.a	No	Strangers	1	1	2	1	1	2
3	8 (1/7)	Hospital	Large	Yes	Team	1	4	2	3	1	6
4	6 (5/1)	NGO	Small	No	Team	2	2	3	2		3
5	6 (3/3)	n.a	n.a	No	Strangers	2	1	2	1	2	4
6	6 (5/1)	Industry	Large	Yes	Team		4	5	1	1	1
7	5 (2/3)	University	Large	No	Team	3	1	1		1	4
8	5 (3/2)	Consultancy	Medium	Yes	Colleagues		2	4	1	2	1
9	8 (2/6)	Health insurance	Large	Yes	Team	2	4	4		2	4
10	5 (2/3)	University	Large	No	Team	2	2	2	1		3
11	7 (5/2)	Health insurance	Large	Yes	Colleagues	1	3	3	1	2	4
Control groups											
12	8 (7/1)	Industry	Large	Yes	Colleagues						
13	6 (6/0)	Industry	Large	No	Team						
14	8 (7/1)	Consultancy	Medium	Yes	Colleagues						
15	8 (5/3)	Consultancy	Medium	Yes	Colleagues						
16	6 (3/3)	Industry	Large	No	Team						
Total	101 (58/43)					15	26	31	12	13	35

Note(s): For the control groups, members' problem-solving preferences were not measured
KE phases: PD: Problem definition; RA: Root-cause analysis; GI: Generate ideas; PI: Plan implementation; I: Implement: CS: Check and sustain
Problem-solving preferences: NT: Visionary-analytic; ST: Realistic-analytic; P: Perceiving; NF: Visionary-harmony; SF: Realistic-harmony and J: Judging
Source(s): Created by authors

subscales; KMO statistic between 0.591 and 0.764, all above 0.5). With the pre-required conditions in place, we conducted exploratory factor analysis and removed those items that had a communality below 0.4 (see Appendix 1). The reliability of the remaining subscales was acceptable to good (Cronbach's alphas, ranging between 0.73 and 0.82 (T1) and between 0.81 and 0.89 (T2)). To measure the individuals' self-efficacy, we used Chen *et al.*'s (2001) scale (eight items, $\alpha = 0.86$ (T1) and $\alpha = 0.93$ (T2), e.g. "Even when things are tough, I can perform quite well"). Both scales, measured on a seven-point Likert scale ranging from 1 "totally disagree" to 7 "totally agree", were included in the same questionnaire. In addition, we retrieved participant characteristics like years of work experience and, for those participating in the treatment groups, MBTI preference type.

To measure KE process quality, all the T2 improvement rounds were videotaped, transcribed and then coded following the codebook described by Franken *et al.* (2021). Each verbal contribution was coded into one of the six KE phases and then plotted over time in a graph to create a KE group process graph (for example, see Figures 2 and 3 in Section 4.1). Then, following Franken *et al.* (2021), KE process quality was calculated by first identifying the values of the jumps between the KE phases (i.e. the number of phases skipped) and then squaring them. A KE-type group needs to demonstrate communicative and coordinative effort to finish one distinct or unique problem-solving phase before continuing onto the next one. Whenever a group jumps to the next phase without finishing the preliminary phase properly, additional effort is required to "jump" back (Franken *et al.*, 2021). The squaring of the jump value is justified by the impact of the skipping phases on the overall quality of the entire KE process. Since a structured group-based problem-solving process, like a KE, can be represented as a value stream (Hicks, 1991; Mohaghegh and Furlan, 2020; Rother and Shook, 2003), skipping a phase is comparable to executing a very low-quality process step. A poorly executed phase has a significant impact on the overall quality of the process because it is determined by the multiplication of each phase's quality (Rother and Shook, 2003). The more KE phases are skipped entirely, the more low-quality ratios must be included in the overall process-quality calculation, resulting in rapidly declining process quality.

In addition, during the semi-structured group interview at the end of the workshop, we collected the participants' own perceptions of the quality of the KE process after having reflected on their own and other group members' behaviours during both improvement rounds. For example, we asked: "How did you experience the collaboration and possible differences between round 1 and 2?" This interview was videotaped and then transcribed.

3.6 Data analysis

Three videos from each group were available for analysis, namely: improvement round 1 (~15 min), improvement round 2 (~15 min) and the final group interview (~15 min). The transcripts of the group interviews were content-analysed deductively, whereby we looked for positive and negative remarks, onto the following literature-based themes (Braun and Clarke, 2006): individuals' self-perceived behaviour (e.g. "Now I stepped in to raise that question"), individuals' self-efficacy (e.g. "I dared to speak up"), group collaboration (e.g. "We listened better to each other") and problem-solving process effectiveness (e.g. "The process was less chaotic"). This enriched our understanding of the effects of the intervention as perceived by the participants.

The videos of the two improvement rounds were first transcribed verbatim; every remark made by any of the participants was written down in order of appearance. Also, observations of behavioural actions were included in the transcripts, e.g. "participant organises his workplace". Next, the transcripts were coded by categorizing every single remark according to one of the six KE phases, following the Franken *et al.* (2021) method. For example, the remark "I think we should change positions" was categorised as a remark in the Idea generation phase. And the previously mentioned observation "participant organises his

workplace" was categorised into the Implementation phase. Finally, all the codes were – in order of appearance – entered onto an Excel sheet, after which a process graph was generated.

To analyse KE process quality objectively, i.e. changes due to the intervention between improvement round 1 and 2, we compared the calculated, video-based coded squared jump value. This indicator provides an objective assessment of KE process quality (Franken *et al.*, 2021). To test the impact of the intervention on KE process quality, a paired samples *t*-test was performed using the calculated squared jump values. In addition, we visually examined the KE process quality differences between the T1 and T2 KE process graphs. Based on the design of our lab-based field experiment, we also used a paired samples *t*-test to analyse two additional control variables related to group effectiveness in problem solving, namely: (1) knowledge of the KE approach, representing Farris *et al.*'s (2009) input factor "kaizen experience" and (2) type of group, as this factor relates to team tenure, a variable in the organisational behaviour (OB) literature that appears frequently related to group effectiveness (Fenner *et al.*, 2023).

To analyse the changes in the individuals' self-efficacy between T1 and T2, we first tested the data for normality (Shapiro–Wilk, T1: $p = 0.380$, T2: $p = 0.499$). As the data were normally distributed, we used a paired samples *t*-test.

To analyse changes in self-reported KE behaviour between T1 and T2, we compared the survey data using a paired samples *t*-test. Regarding the treatment groups, we could perform a more in-depth analysis based on our assessment of their MBTI preferences. Per MBTI preference type, the changes between T1 and T2 in perceived behaviour per KE phase were analysed (see Figure 1). The MBTI preference types, namely NT, ST, NF and SF, were used to analyse behavioural changes in the KE phases, Problem definition, Root-cause analysis, Plan implementation and Implement. The P and J MBTI preference types were used to analyse behavioural changes in the Generate ideas and Check and sustain KE phases. We first checked for normal distribution. As this data was not normally distributed (Shapiro–Wilk between <0.001 and 0.099), we used a Wilcoxon test to examine potential significant changes between T1 and T2.

4. Findings

4.1 Kaizen Event process quality before and after the intervention

The calculated squared jump values per KE group between T1 and T2 are presented in Table 3. The results show that all the treatment groups' squared jump values went down at T2, whilst only three control groups had lower squared jump values (groups #13, #14 and #16), and the other control groups' scores were even higher (groups #12 and #15).

The paired samples *t*-test showed a significant change in squared jump values when all the groups' samples were combined (Table 4). When divided into treatment and control groups, a significant change in squared jump values was found for the treatment groups but not for the control groups (Table 4). Those findings offer a first indication that enriched awareness of one's own and group members' problem-solving preferences is positively related to an improvement in KE process quality among treatment groups after being stimulated by the intervention between T1 and T2.

This KE process quality improvement and the difference between treatment and control groups were also visible in the objective KE process graphs of the improvement T1 and T2 rounds (Figure 2). For example, KE group 4, a treatment group, followed the sequential KE phases in a more orderly manner in improvement round 2 than improvement round 1. We also video-observed that, in the first improvement round, some KE treatment groups (e.g. groups 5 and 6) split their discussion (unconsciously) into multiple, not aligned (sub-group) discussions. In the second improvement round, the discussions among both KE groups were much more aligned. However, control group 16 had many more sub-group discussions in improvement round 2 than in improvement round 1 (Figure 3).

Finally, we explored if any differences in KE process quality were due to other factors than our intervention. Hence, we compared the groups based on their level of "knowledge of the KE

Table 3. Overview of squared jump values obtained during the workshop's improvement rounds: treatment vs control groups

			KE group number Treatment groups											Control groups				
	Mean	SD	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Squared jump value T1	93.31	33.51	70	88	72	62	157	137	52	124	137	63	56	122	102	74	107	70
Squared jump value T2	66.13	30.97	60	57	36	42	58	76	32	44	102	34	24	95	104	103	68	123
Difference T1–T2	27.18	2.54	10	31	36	20	99	61	20	80	35	29	32	26	−2	−29	39	−53

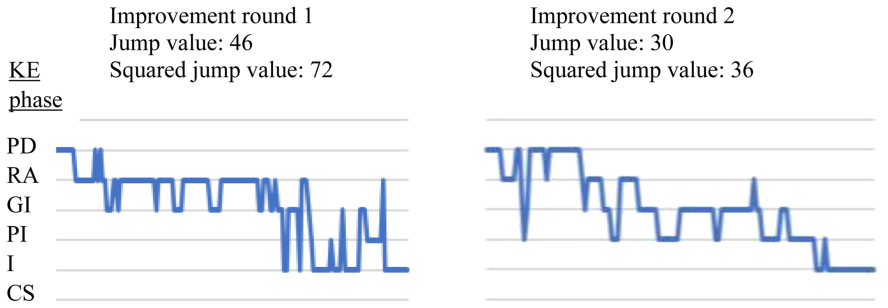
Source(s): Created by authors

Table 4. Comparisons between KE groups

KE group process quality – squared jump value															
	All groups (N = 16)					Treatment groups (N = 11)					Control groups (N = 5)				
Variable	Mean T1	SD T1	Mean T2	SD T2	p	Mean T1	SD T1	Mean T2	SD T2	p	Mean T1	SD T1	Mean T2	SD T2	p
Squared jump value	93.31	33.51	66.13	30.97	*0.010*	92.55	38.51	51.36	22.64	*<0.001*	95.00	22.29	98.60	19.96	0.843
	All Groups (N = 11)					Value A (N = 6)					Value B (N = 5)				
A: No knowledge of KE B: Knowledge of KE	92.5	38.5	51.4	22.6	*<0.001*	82.0	38.6	47.2	12.7	*0.046*	105.2	38.4	56.4	31.9	*0.006*
A: Existing teams B: Groups of strangers/ colleagues	92.5	38.5	51.4	22.6	*<0.001*	87.2	39.1	53.6	28.8	*0.003*	99	41.2	48.6	15.1	*0.039*

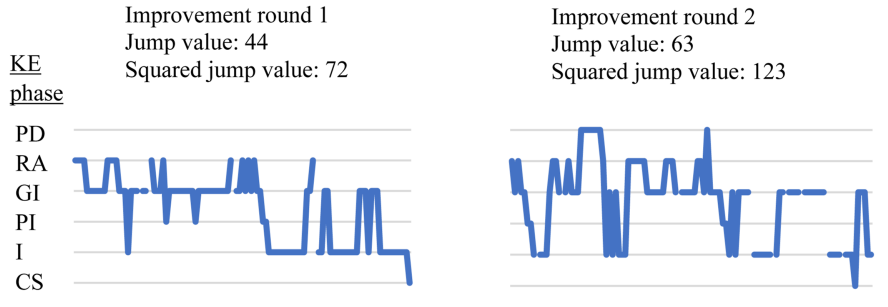
Individuals' self-reported variables															
	All groups (N = 16)					Treatment groups (N = 11)					Control groups (N = 5)				
Variable	Mean T1	SD T1	Mean T2	SD T2	p	Mean T1	SD T1	Mean T2	SD T2	p	Mean T1	SD T1	Mean T2	SD T2	p
Self-efficacy	5.39	0.90	5.57	0.78	*0.001*	5.47	0.80	5.58	0.82	*0.030*	5.25	1.05	5.53	0.70	*0.010*
KE behaviour	5.23	0.57	5.07	0.59	*<0.001*	5.28	0.56	5.02	0.64	*<0.001*	5.13	5.74	5.15	0.49	0.738

Note(s): Values in italics are significant, $p < 0.05$
Source(s): Created by authors



Source(s): Created by authors

Figure 2. Example of KE process graphs comparing improvement round 1 and 2 (KE group 4 – treatment group)



Source(s): Created by authors

Figure 3. Example of KE process graphs comparing improvement round 1 and 2 (KE group 16 – control group)

approach" and "type of group" (team vs colleagues/strangers); see Table 4. Although the groups were slightly different, the quality of the KE processes appeared to be significantly different, meaning that the positive relationship between an awareness of the group members' problem-solving preferences and KE process quality does not depend on the level of knowledge of the KE approach or the type of group.

The group interviews corroborated these findings: All the treatment groups' participants experienced an improvement in problem-solving process between improvement round 1 and 2. The groups mentioned they had more focus on the goal (groups 5, 6, 7, and 11) and paid more attention to understanding the problem (group 11). All the groups noted differences in the improvement process. For instance, they referred to the process in their second improvement round as being "less chaotic" (groups 2, 4 and 9) in which they "listened to each other" more (groups 1, 2, 3 and 6), "explored others' opinions better" (group 8), "took time to analyse the causes" (groups 3, 4, 5 and 10) and did not "jump to action without exploring the causes" (groups 6 and 11). The group members also became more aware of their own preferences and the group's task interdependencies as they then saw the need for their peers to raise questions that they would not consider asking themselves. As mentioned by a participant with a realistic-harmony (SF) preference: "I still do not like questions exploring the root-causes, but I now know they are important for the process." When we asked whether their increased awareness of problem-solving preferences would contribute to achieving KE results and operational performance improvement, the teams responded positively; one participant even stated immediately: "Definitely!" Overall, the groups were positive when asked if the provided

knowledge had improved their problem-solving process. The objective and perceptual data indicated that the intervention, which was meant to increase each participant's awareness of everyone's problem-solving preferences, positively influenced KE process quality.

During the control group interviews, almost no remarks were made regarding individuals' behaviours in the collaboration. Instead, the participants mostly discussed perceived differences between improvement round 1 and 2 related to the task and the solutions, like "I needed help with folding so I asked my colleagues who were not that busy", "In the second round, small and bigger solutions were discussed simultaneously, which made it more chaotic" and "In the second improvement round, you also separated yourself from the group". The participants appreciated the fact that, during the workshop, attention was paid to the improvement process. When specifically asked whether they behaved any differently, no remarks came up. Group 14 even noted that the second improvement round felt *less* structured than the first.

4.2 Individuals' self-efficacy before and after the intervention

Between T1 and T2, the mean self-reported self-efficacy ($N = 101$) of both the treatment and control groups participants had improved significantly (Table 4). This indicates that paying attention to the improvement process might relate to building self-efficacy in problem solving. The interviews, however, revealed the differences in the types of groups. Within the treatment groups, remarks were made using words related to self-efficacy, like "I trust" or "I dare" (Bandura, 1982). The participants mentioned, for instance: "As the others know my strength, I now dare to speak up", "I was aware that someone had to ask the question, so I did" and "I feel more connected to the group". Those self-efficacy signal words were not used by any of the control groups. So, even though both group types demonstrated a significant change in self-efficacy, the change may be driven by a different driver.

4.3 Self-reported problem-solving behaviour before and after the intervention

Finally, we identified the significant differences between the individuals' self-reported KE behaviours before and after the intervention. First, the differences in self-reported KE behaviours among both groups between T1 and T2 were analysed (Table 4). The results indicate that being aware of one's own and group members' problem-solving preferences seems to be related to self-reported KE behaviour. The participants of the control groups did not show any significant changes in self-reported KE behaviour, which means that only focusing on the improvement process does not have the same impact as developing one's awareness of problem-solving preferences. Being aware of one's own and group members' problem-solving preferences may influence individuals' behaviours and, thus, KE process quality (corroborated by the improved KE process quality findings, as presented in Table 3).

Since the treatment group members were aware of their MBTI problem-solving preference, we conducted a more detailed analysis of changes in self-reported behaviour across the KE phases. The results are presented in Table 5.

Significant reported behavioural changes were found in all the KE phases. It appears that, when an individual was made aware that a specific phase during an intervention did not match their problem-solving preference, they actually changed their problem-solving behaviour: Individuals seemed to become less active during those phases that did not match their preferences and, indeed, left it to other group members to take the lead. For example, individuals with a SF preference (which matches the Implement phase) reduced their contribution to the Problem Definition phase from 5.33 (T1) to 3.79 (T2) (Table 5). They seemed to leave the exploration of the problem during this phase to others. Individuals with an NT preference, on the other hand, left the Plan Implementation phase to qualified peers, as also shown by their lowered self-reported score, from 5.23 (T1) to 4.58 (T2) (Table 5).

These findings of the treatment group participants were corroborated by our video footage. For instance, in improvement round 2's tape of KE group 5, two participants with a strong

Table 5. Mean Differences, T1 vs T2, in self-reported behaviours per KE phase

	KE phase																
	Problem definition			Root-cause analysis			Generate ideas			Plan implementation			Implement			Check and sustain	
Preferences	T1	T2	*p*	T1	T2	*p*	T1	T2	*p*	T1	T2	*p*	T1	T2	*p*	T1	T2	*p*
NT	5.58	5.52	0.754	5.52	5.62	0.262				5.23	4.58	*0.001*	4.98	4.58	*<0.001*			
ST	5.97	5.53	*0.014*	5.56	5.41	0.176				5.61	4.92	*<0.001*	5.26	4.79	*0.042*			
NF	5.90	5.23	0.063	5.64	4.97	*0.037*				5.73	5.71	0.894	5.90	5.77	0.491			
SF	5.33	3.79	*0.003*	4.78	3.80	*0.017*				5.77	4.88	0.071	5.81	5.50	0.110			
P							5.71	6.15	*0.002*							4.76	4.26	*0.010*
J							4.74	4.68	0.601							5.18	4.96	0.186

Note(s): Values in italics are significant, $p < 0.05$ (two-tailed)
Source(s): Created by authors

focus on the Implementation phase (SF) showed they listened when a group member analysed the root causes, whereas they had ignored this colleague in the first improvement round. The interviews confirmed this effect, as the participants noted: "I am now aware of my strength" and "I now appreciate the questions asked by others". Also, the participants who had facilitated a KE before noted: "As a facilitator, I have to make sure that I focus on all KE phase questions, and not only on the ones that have my personal primary interest". The findings also showed that, when participants were in their preferred phase, no major behavioural changes were reported, e.g. individuals with a preference for the Problem definition (PD) phase reported no significant change between T1 and T2. However, individuals with a SF preference gave themselves a lower score for their preferred Implementation phase. This might be explained by some critical remarks made during the interviews: "Now I feel the obligation to guide the group through this phase, as it is my preferred phase. This might be stressful" and "as this new knowledge changes the way we normally solve a problem, it feels uncomfortable".

Overall, we can conclude that becoming aware of one's own and group members' problem-solving preferences leads to improved KE process quality.

5. Discussion

Given the importance of high-quality problem-solving processes for realising process improvements, we explored how individuals' differences contribute to KE process quality (Farris *et al*., 2009; Flynn *et al*., 2010; Liker, 2004). We explored if KE process quality would be enhanced after a better understanding of how a group's problem-solving process emerges from individuals' problem-solving preferences and group-member differences (Kozlowski and Ilgen, 2006). By means of an intervention, we raised KE group members' awareness of their own and peers' problem-solving preferences; we taught them how those preferences relate to problem-solving behavioural needs in the six different phases of a KE. On comparing the treatment with the control groups, we actually found a positive relationship between KE process quality and group member awareness of own and other group members' problem-solving preferences. Below we explicate how the findings advance our knowledge and theory in relation to problem solving and KEs.

5.1 Theoretical implications

Problem solving and KEs are widely studied topics in OM research, as an organisations' capability to improve operational performance effectively is key. In the well-known and often used Farris *et al*. (2009) KE model, tool quality and KE process quality are considered to be factors for success (Aleu and Van Aken, 2016; Farris *et al*., 2009; Franken *et al*., 2021). We know from the OB theory of small groups that group processes emerge from individual group members' behaviours (Kozlowski and Ilgen, 2006), and this is supported by a group's shared mental models (Carraro *et al*., 2024; Fenner *et al*., 2023). In our field-based lab experiment, we combined those insights and specifically studied the individual member's level in a problem-solving group: The impact of group awareness of members' problem-solving preference differences is an important variable in achieving high KE process quality. Our findings do point out that such a shared awareness of individuals' problem-solving preferences is a key factor contributing to high quality in a group's KE process. So far, the KE theory (Farris *et al*., 2009; Franken *et al*., 2021) has overlooked individual-level variables as antecedents of KE process quality. Thus, this study extends the KE model by connecting existing theories from the OM and OB domains, adding a new individual-level factor to the (practically relevant) KE success factors and an organisation's problem-solving initiatives.

Another theoretical contribution of this study is that a group's problem-solving behaviour is affected and improved by the feedback individual members receive during KE iterations and how that influences KE process quality further. KE models are often conceptualised with an Input-Process-Output representation (Farris *et al*., 2009). But our study shows that KE process

quality improves based on feedback on the process during KE iterations. A conceptualisation based on the Input-Mediator-Output-Input model, a model that already gained traction in OB theory almost 20 years ago (Ilgen *et al*., 2005), is therefore proposed to better represent a KE.

Our findings indicate that raising one's awareness of personal problem-solving preferences is likely to increase one's self-efficacy in problem solving. This link is supported by the social-cognitive theory and, specifically, the impact of self-efficacy on task behaviour (Bandura, 1991; Judge *et al*., 2007). The social-cognitive theory posits that human behaviour is especially motivated and regulated by self-efficacy (Bandura, 1991). From their belief in what they are capable of, people will consider their behavioural actions. In the context of problem solving, this theory implies that one's self-efficacy in problem solving will support an individual's active contribution to a group problem-solving process. The social-cognitive theory explains how self-efficacy grows from a self-awareness of variables such as general mental ability, conscientiousness, knowledge and experience of how behaviour facilitates interpersonal interaction (Bandura, 1982; Caldwell and Hayes, 2016; Edmondson, 1999; Judge *et al*., 2007). Our results show that an awareness of one's problem-solving preferences and the experience of how one's problem-solving behaviour is valued by the group boosts self-efficacy in problem solving, which, in turn, leads to displaying (more effective) individual problem-solving behaviours in the various KE phases.

Also, from a group-level perspective, the complex adaptive systems theory explains how group behavioural patterns are inherently dynamic and how group behaviour emerges from individuals' behavioural patterns as well as how individuals' behaviours are influenced by the group's dynamics (Cronin *et al*., 2011; Hoogeboom and Wilderom, 2020; Kozlowski, 2015). This implies that, whenever an individual's behaviour changes, the group's dynamics will change too. Conversely, individual behaviours will change as a consequence of changing group dynamics. The recursiveness of group interactions is reflected in our findings as well as in the complex adaptive systems theory. Comparisons of the T1 self-reported behaviours with those at T2 show that individuals see themselves behaving differently after having received the feedback on their personal problem-solving preferences. Together with the video coding, we uncovered that more awareness of these preferences leads to improved individual and group behaviours, in turn leading to higher group problem-solving process quality. Whereas most complex adaptive systems studies focus on the intricacies of crafting effective group dynamics, this study has uncovered the individual-level foundations of such group dynamics and cross-level interactions.

Indeed, we know that group problem-solving behaviour emerges bottom up, from individuals' behaviours (Caldwell and Hayes, 2016; Edmondson, 1999; Kozlowski and Ilgen, 2006; Wageman *et al*., 2005). At the same time, it is not just an individual's self-efficacy in problem solving that drives their behaviour; the relationship between their behaviour and the resulting group problem-solving behaviour is also influenced by a group's shared belief that, as a group, they are capable of executing the task at hand (Carraro *et al*., 2024; Mathieu *et al*., 2017; Monteiro and Vieira, 2016). Katz-Navon and Erez (2005) showed that the more group members experience task interdependency, the more "group efficacy" moderates group performance. Hence, connecting our findings to theory, we realise that our method of revealing all the group members' problem-solving preferences to them and how these behavioural preferences are needed in each KE phase may have created a higher level of group task interdependency. The group members became more aware of their own preferred KE phase (or "strengths") related to their problem-solving preferences. Yet, they also realised how vital their peers' problem-solving preferences were for a high-quality process. This shared awareness may have positively accelerated individual contributions to high-quality group problem-solving.

All in all, our focus during this field-based lab experiment was on how to improve KE group problem-solving process quality. Studying KE group problem-solving quality and the specific KE phases, using also video observation, is a novel approach that deserves future studies

combining the OM and OB disciplines to advance what we know about increasing the effectiveness of organisationally relevant process improvement.

5.2 Practical implications

Problem-solving skills are key to organisations' process improvements. Structured problem solving is difficult to do well (Mohaghegh and Furlan, 2020; Tucker *et al*., 2002). It often requires hard work from an external facilitator to keep a group within the boundaries of an effective KE process. Such facilitators can be costly. Also, viewed from that angle, it is important that group participants in structured problem-solving events, like KEs, are supported in developing their problem-solving process skills to become more effective and autonomous (Fenner *et al*., 2023; Stone, 2010). A first step to developing those skills is to make people more aware that problem-solving is a process. This can be done practically by not only assigning a group the task to improve a specific situation but also by getting them to discuss and report afterwards how well the standardised problem-solving process was followed. If a group jumps to ideas without exploring the root causes, it might give a first impression of how the group is doing. A second step can be to provide training on the group members' preferred problem-solving styles, as with the MBTI intervention reported herein, in combination with the outcome of this study. Making group members aware of their own and other members' preferred problem-solving preferences, each associated with personal strengths in specific KE phases, can enable groups to have good discussions about KE process quality; to develop their KE process capabilities further and to leverage each participant's strengths in the process. By using individual problem-solving preferences and also objective KE-process visualisations, a better group and individual reflection on KE-process quality may occur, which may enrich members' group problem-solving skills. Therefore, we advise KE-trainers to incorporate (group) problem-solving skill development in their curriculum. For example, lean practitioners could add a module on problem-solving preferences to a Lean green belt course. Also, leadership development programmes may be enriched by offering more understanding of their personal preference of a problem-solving phase, next to learning how to reflect on (group) problem-solving process quality and even using those insights when composing problem-solving teams.

KE facilitators can also benefit from being trained on how group members' problem-solving preferences influence KE process quality, which will expand their capabilities to guide KE groups better (Pierce *et al*., 2000). Group facilitators should also be aware of their own personal preferences in problem-solving processes to avoid bias in the facilitation of groups' problem-solving processes.

Finally, KE groups are only brought together to solve a particular problem within a short time frame (Farris *et al*., 2009). The members might be strangers upon entering the KE group whilst, at the same time, they might lack the time to go through Tuckman's group forming, storming, norming and then performing phases (Bonebright, 2010; Liu *et al*., 2015; Santos *et al*., 2015). Hence, it would be beneficial for group members to share their problem-solving preferences before or when they start a KE event to speed up becoming a high-performing group.

6. Strengths, limitations and future research

In this mixed-methods, field-based lab experiment, we gathered greatly different types of data, based on which we established how KE process quality can be enhanced. Raising awareness of one's own and the group members' preferences can change all the members' problem-solving behaviours and increase self-efficacy. Due to our feedback-type intervention, the treatment groups' KE process quality improved. By sampling heterogenic teams, we made sure that, during the workshop, relevant problem-solving behaviours became visible in the treatment groups that were related to the different problem-solving preferences. A limitation of this study

is the relatively small number of groups but, nevertheless, it offers statistically significant results in the anticipated direction. Expanding the study to more KE groups would probably lead to similar conclusions, but replication is recommended.

The results of this study also imply a learning curve effect. Many of the groups, treatment as well as control groups, adjusted their second round of problem-solving, e.g. by appointing a facilitator. This was done based on a group's reflection that the first improvement round was too "hectic" and "chaotic". As this reflection led to an adjusted way of working, it can be inferred that the group had learnt (Shute, 2008). Also, the self-efficacy scores show a significant improvement in both the treatment group and control group participants, meaning that the individual participants felt they had learnt. Although our study focused on and supported the impact of problem-solving preference awareness on KE process quality, the initial insights related to (individual-level) learning provide an interesting perspective for further research. In light of the fact that operational organisational issues need to be solved faster nowadays, it is relevant to know more about how group members acquire KE skills, possibly per phase and/or their overall KE simulation experience. For example, one could think of conducting longitudinal research on how KE group members grow their (operational or other) problem-solving capabilities from being a beginner to advanced.

Another interesting direction for future research would be to test the impact of known team effectiveness variables on the group's problem-solving process, for example, group autonomy (Farris *et al*., 2009) or trust (Fenner *et al*., 2023). Also, the impact of group homogeneity in terms of problem-solving preferences is an interesting angle. We sampled heterogenic KE groups, but real-life KE groups might not be so diverse (Bendor and Page, 2019; Stone, 2010). Furthermore, similar future field research should include more objective or other KE performance measures, e.g. saved organisational costs, percentage of problems solved and real-world variables like time constraints, budget limitations, trust and the nature of a company's continuous improvement strategies (Allen and Lehmann-Willenbrock, 2023; Arellano *et al*., 2021; Negrão *et al*., 2016; Netland and Ferdows, 2016). Moreover, we need to explore how group members score their own behaviour in their preferred and non-preferred problem-solving phase, possibly by a think-aloud approach when filling in a post-workshop questionnaire (Van Someren *et al*., 1994). A longitudinal field study must assess the long-term (performance) results after a KE group process quality intervention.

In sum, our research expands on what we know about how individual problem-solving preferences impact KE group process quality. It increases our theoretical understanding of how to manage a KE well whilst immediately contributing to participant learning. More of such research might bridge the gap between theorizing about and contributing directly to solving complex operational issues.

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Appendix 1

Table A1. Survey items on each of the six KE phases

Sub scale	Items	
Problem definition phase	PD1	I ask questions in order to understand what the real problem is
	PD2	I ask questions to understand why a certain disparity is a problem for the organization
	PD3	I ask questions to estimate what the factual consequences of a disparity could be
	PD4	I ask questions to determine why a disparity is a problem at this point in time
Root-cause analysis phase	RA1	I keep asking questions to find the root cause of a problem
	RA6	I think it is important to analyse possible root causes thoroughly
	RA7	I believe that you cannot make a decision about what should be solved, without a thorough root cause analysis
	RA8*	It annoys me when team members start discussing the implementation when we have not finished the root cause analysis
Generate idea phase	GI9	I have ideas about how to solve the root cause of a problem
	GI10	I share my problem solving ideas without being influenced by possible restrictions
	GI11	I can suggest out-of-the-box solutions
	GI12	I enjoy coming up with creative solutions with everyone
	GI13*	I can assess whether an idea will really solve a root cause
	GI14*	It annoys me when team members say they cannot think of more solutions, after just 1 or 2 ideas
Plan implementation phase	PI15	I ask questions about the current situation to gain a proper understanding of how the work-floor employees will react to a proposed change
	PI16	I think about what work-floor employees need before they can start working with a solution
	PI17*	I think it is important that an implementation plan is achievable
	PI18*	I ask questions about the preconditions that need to be fulfilled before a solution can be implemented
	PI19	I ask questions about who needs to be involved in the decision making, in order to implement a solution successfully
	PI20	I think it is important to discuss and decide on the end result of a change
Implement phase	I21*	I like implementing a solution
	I22	I talk to work-floor employees to get their opinions about a change
	I23	I talk to work-floor employees to see if a solution can be implemented
	I24	When I receive any signals that an implementation is not going well, I discuss it and, if necessary, take action
	I25*	I keep an eye on the progress of a plan and make adjustments where necessary
	I26	I make sure that no friction arises during the implementation of a solution
Check and sustain phase	CS27	I make sure that we stick to the scope of what we want to implement
	CS28*	I ask questions to find out whether we have ensured that a new method will last
	CS29	I check whether all the elements of an aspired end result have been achieved
	CS30	I make sure that we report the end result of an implementation
	CS31	I make sure that we close a project properly
	CS32*	After implementing the solution, I ask if the problem is solved good enough

Note(s): The lead question of this survey was: "In general, when you are a member of a group that has to solve a problem, which statement is applicable to you?" All items were scored on a 7-point Likert scale with 1: totally disagree to 7: totally agree

*Items excluded based on exploratory factor analysis (communality to sub-scale <0.4)

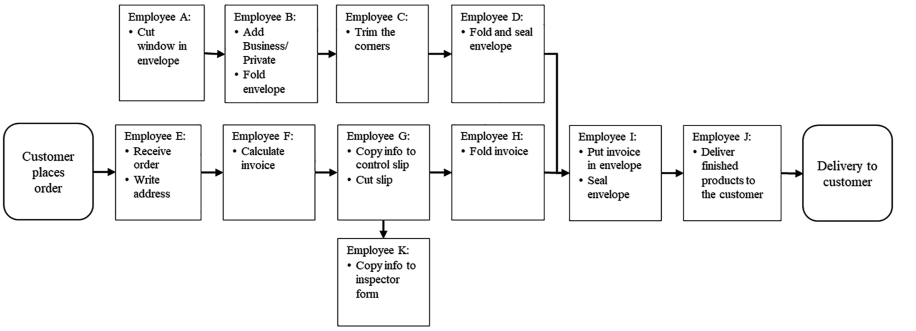
Source(s): Created by authors

Appendix 2

Explanation of the simulation game: @dministration

The aim of the @dministration Lean simulation game is to demonstrate the various Lean types of waste in organisational processes and the impact on performance improvement when eliminating them. Additionally, the game facilitates discussions of effective group problem solving. Typically, the game is used to explain and enable the participants' first-hand experiences of the impact of applying the Lean principles, such as customer value, value stream, flow, pull and perfection. However, the game can also be used to create more awareness of group behaviours like group learning, collaboration and group problem solving.

The simulation game requires a minimum of four and a maximum of 15 participants, and each participant is assigned a specific task. The process that the participants are asked to follow (and later improve) is to create invoices for clients. As shown in Figure A1, the process starts with the reception of a customer order, after which the participants must prepare the correct invoices, put each invoice in an envelope and deliver it to the customer. Every round entails the customer sending 15 orders, each of which necessitates one to three separate invoices being drawn up. The participants are responsible for producing both the invoices (using a standard template) and the envelopes (which start with a sheet of A4 paper).



Source(s): Created by authors

Figure A1. Overview of employee tasks in @dministration simulation game

At the start of the game, all the participants receive their personal standard operating procedure instructions on how to execute their assigned task(s). Depending on the available number of participants, the tasks can be combined or split. If there are less than six participants, the facilitator takes on the customer role. The standard three-hour workshop entails the participants executing three production rounds, with two improvement rounds in between them. Each production and improvement round takes about 15 min. In a production round, orders appear automatically on the presentation screen, at a rate of one order per minute.

Many different types of waste have been designed in the simulation game and naturally appear during the first production round, such as confusing standard operating procedures, unbalanced workloads between the participants and poor-quality materials. Usually, only one order is realised in the first round, often of unacceptable quality. Typically, during the final production round at the end of the game and after having received instructions related to Kaizen problem solving and the different types of waste, most of the groups are able to deliver 12 out of the total 15 orders to their customers. This simulation game served as an appropriate setting for our intervention study, whereby we added the intervention before improvement round 2 (see Table 1, agenda item 5) to create awareness of KE problem-solving preferences. The intervention slides can be found in Franken (2024, pp. 177–181).

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