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# Designing a Knowledge-Driven Team Development Framework Based on the Psychological Safety Capability Maturity Model

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## Abstract

This study developed the Psychological Safety Capability Maturity Model (PS-CMM) as a knowledge-driven team development framework. PS-CMM standardizes efforts to improve psychological safety, which tend to become dependent on individual initiatives, by positioning them as team-based practices. It is structured so that teams can take a multifaceted approach to promote psychological safety. After applying the PS-CMM for four weeks to Japanese student sports teams—one type of team characterized by strong top-down decision-making and difficulties in knowledge management—psychological safety related to mental health showed a statistically significant improvement ($p < .001$). Qualitative analysis further indicated that team psychological safety improved and that members experienced reduced psychological barriers to communicating with coaches and core members. These findings contribute to the development of evidence-based intervention methods for improving psychological safety and propose a knowledge-driven team development framework that standardizes individual-dependent initiatives, thereby advancing knowledge management.

*Keywords:* Capability Maturity Model, Psychological Safety, Team, Knowledge Management

## 1 Introduction

Encouraging team members to share ideas and voice concerns while reducing silence around failures is vital for effective team functioning [1]. Psychological safety (PS), the shared belief that a team is safe for interpersonal risk-taking [2], assures members that speaking up or challenging ideas will not harm their standing [3]. PS promotes knowledge sharing and team learning and improves decision-making and performance [4]. PS is particularly critical in non-routine or uncertain situations [5], and meta-analyses have confirmed its positive effects on learning, voice, creativity, proactive behavior, and openness at both the individual and team levels [2, 6].

Sport teams can be conceptualized as an "extreme team environment" from the perspective of PS, as they possess structural characteristics that simultaneously demand competition and collaboration, involve steep power hierarchies, and are subject to immediate evaluation—factors that make PS both highly vulnerable and highly malleable at the same time. Competitive principles make performance public and consequences real; poor results may

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lead to benching or loss of status [7]. These conditions render sports environments inherently psychologically unsafe [7]. Athletes, fearing negative outcomes, often hesitate to question coaches or discuss their issues [8]. Accordingly, sport teams constitute a theoretically valuable research context for examining the validity and generalizability of PS theory and its intervention models, potentially even more so than corporate organizations. Sports teams must respond rapidly to uncertainty during competitions, which requires open communication and knowledge sharing across coach–athlete boundaries. Establishing a psychologically safe environment is essential to integrate diverse experiences and foster adaptive team learning. In recent years, the accumulation of empirical evidence on psychological safety in the sport domain has steadily progressed. Specifically, psychological safety has been shown to enhance teamwork and alleviate burnout [9], and higher levels of psychological safety have been observed in teams with superior performance outcomes [10]. These findings suggest that psychological safety has the potential to positively influence both team performance and athletes' mental health. Collectively, psychological safety in sport functions as a foundational element of effective team building.

Edmondson & Bransby (2023) identified six priorities for advancing PS research [11]. The greatest gap concerns how PS is created, making intervention research a central topic [11]. In the sports context, where hierarchical dynamics and competitive pressure can hinder communication, there is a strong need for evidence-based methods to build a PS [12]. Building PS in highly uncertain contexts requires enhancing PS within those very contexts. Because PS is a component of team climate, it cannot be fostered through one-off or sporadic initiatives alone (e.g., lectures or training sessions) [4]. What is required instead is an approach that enables such previously ad hoc efforts to be implemented on a continuous and repetitive basis, and that standardizes them as organizational and team-level practices rather than relying on individual initiative. Furthermore, because the success of interventions aimed at enhancing PS is highly context-dependent, a knowledge-driven approach is required—one that consolidates practical, on-site knowledge while systematically examining initiatives to foster team PS. To do so, teams need a knowledge-structuring model that systematizes and shares experience-derived know-how. Therefore, this study proposes a Capability Maturity Model (CMM) centered on PS—Psychological Safety Capability Maturity Model (PS-CMM)—to foster continuous learning and improvement. Because team PS should be cultivated as an ongoing organizational process, not via one-off training, the CMM's premise of stepwise process maturation offers an effective framework for capturing PS development [4, 13, 14]. We developed the PS-CMM as a knowledge framework. PS-CMM organizes the knowledge generated from team experiences and learning, enabling teams to codify, share, and iteratively refine practices that enhance PS. Leveraging the CMM structure allows tacit improvement practices to be formalized and accumulated as reusable team knowledge [13, 14]. The evidence of its effectiveness in sports establishes a foundation for a portable team development framework that can be extended to other domains, supporting knowledge sharing, team learning, and sustained PS growth.

# 2 Development of Intervention Methods for Psychological Safety

## 2.1 Organizing Requirements for Psychological Safety Intervention Methods

Intervention outcomes for PS vary according to the population and method. To address this, Kotani et al. (2025) outlined six requirements for PS interventions: (1) increased participation, (2) intervention at the team level, (3) alignment with the team context, (4) structural communication, (5) use of third-party facilitation, and (6) application of mixed-methods evaluation [15]. Moreover, Frazier et al. (2017) [6] noted "countless" antecedents influence PS, underscoring its complexity. As PS is a part of the team climate, effective change requires medium- to long-term effort rather than one-off training [4]. In short, the PS intervention design must satisfy multiple demanding criteria that prior studies have rarely met simultaneously. Combining the third requirement from Kotani et al. (2025)—alignment with the intervention context—with the assertion by Frazier et al. (2017) yields the following requirement: "The ability to select antecedents of psychological safety that align with the target team's context from among numerous antecedents" [6, 15]. Adding the requirement for a medium-to-long-term approach is necessary [4]. The requirements for developing psychological safety intervention methods can be consolidated into the following six categories: (1) participation in the intervention method is mandatory; (2) the intervention targets all team members; (3) the intervention approaches antecedents of psychological safety that align with the context of the target team from among the numerous antecedents; (4) facilitate communication flow during intervention implementation through third-party involvement; (5) implement continuous psychological safety interventions; and (6) employ a mixed-methods approach for pre- and post-intervention comparisons. To meet these requirements, this study developed a PS-CMM using a Capability Maturity Model.

## 2.2 What and Why of the Capability Maturity Model

The Capability Maturity Model (CMM) is a framework for organizational process improvement proposed by the Software Engineering Institute at Carnegie Mellon University [13, 14]. Five maturity levels are defined at the organizational level, and at each level, Key Process Areas (KPA) specify the goals (and key practices) to be achieved (Table 1) [13]. The horizontal axes of Table 1 (A-11-1 to B-12-2) represent the KPAs, indicating the areas on which organizations should focus. The vertical axis (maturity levels 1 to 5) represents the maturity levels. The five stages of maturity are shown for each KPA, and the state to be achieved at each maturity level is specified [13]. However, these specifications are purely conceptual and generalized. They do not describe the specific practical tasks or procedures to be performed during software development [14]. Moreover, CMM specifies "what" to do, but not "how" to do it [14]. Next, we describe the five maturity levels.

The maturity levels range from level 1, the lowest and least mature state, to level 5, the highest and most mature state [13]. Level 1 (initial) is a stage in which processes are ad hoc and undocumented, and outcomes depend on individual heroics; Level 2 (repeatable) is a stage in which basic project management disciplines concerning schedule, cost, and requirements are established, enabling the repetition of past successes; and Level 3 (defined) is the stage in which organizational standard processes are documented and applied to all projects under education and tailoring guidelines. In Level 4 (managed), the process and product quality are managed using statistical methods, such as defect density, based on quantitative objectives. In Level 5 (optimization), continuous improvement is achieved through root cause analysis, defect prevention, and technology/process change management

[13].

Using KPAs and maturity levels, teams can prioritize psychological safety antecedents within their organizational context and continuously enhance their climate through incremental maturity improvements. Furthermore, using the CMM framework enables the achievement of Requirements 3 and 5. This is because organizing the antecedents of psychological safety and listing them as KPAs allows the target team to select the most important KPAs with high priority for their team from the overall picture of antecedents. Consequently, antecedents aligned with the team context can be chosen. Furthermore, by examining the practices related to the selected KPAs and pursuing improvements from a maturity levels perspective, teams can move beyond isolated or sporadic practices to achieve continuous practice improvement and implementation. Applying the CMM framework to the developmental process of psychological safety enables the explicit design of a process for teams to progressively mature their psychological safety.

## 2.3 Development of Psychological Safety Capability Maturity Model

This study developed a Psychological Safety Capability Maturity Model (PS-CMM) using the CMM. We defined the Key Process Area (KPA) and maturity levels of the PS-CMM. The KPAs are structured by referencing a review that systematized the antecedents of psychological safety in sports teams [16] (Table 2). Furthermore, the definitions of maturity levels in the PS-CMM are based on the definitions of maturity levels in the CMM. Finally, we individually defined the maturity levels for each of the 13 KPAs according to the defined maturity levels and designed the PS-CMM (Table 3).

Table 1: The CMM Framework

| Maturity Level | KPA A-1 | | | | KPA B-1 | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | KPA A-11 | | KPA A-12 | | KPA B-11 | | | KPA B-12 | |
| | KPA A-11-1 | KPA A-11-2 | KPA A-12-1 | KPA A-12-2 | KPA B-11-1 | KPA B-11-2 | KPA B-11-3 | KPA B-12-1 | KPA B-12-2 |
| Level 5 | | | | | | | | | |
| Level 4 | | | | | | | | | |
| Level 3 | | | | | | | | | |
| Level 2 | | | | | | | | | |
| Level 1 | | | | | | | | | |

Table 2: Thirteen PS-CMM Key Process Areas (sport-specific antecedents)

| Environmental factors | | Organizational factors and program design | | Interpersonal factors | | | | | | | Intrapersonal factors | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Social support | | Vulnerability | Team identification | Incivility | | Interpersonal relationships | | Accountability | Coach consistency | Coach transformational leadership | Members' communication qualities | |
| people close to you | expert | | | Teammates | Coach | Teammates | Member and coach | | | | Athlete conflict management | Athlete openness |

Table 3: Overview of PS-CMM

| Maturity Level | Environmental factors | | Organizational factors and program design | | Interpersonal factors | | | | | | | Intrapersonal factors | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Social support | | Vulnerability | Team identification | Incivility | | Interpersonal relationships | | Accountability | Coach consistency | Coach transformational leadership | Members' communication qualities | |
| | people close to you | expert | | | Teammates | Coach | Teammates | Member and coach | | | | Athlete conflict management | Athlete openness |
| 5 | Optimizing our efforts based on the data obtained. | Optimizing our efforts based on the data obtained. | Optimizing our efforts based on the data obtained. | Optimizing our efforts based on the data obtained. | Optimizing our efforts based on the data obtained. | Optimizing our efforts based on the data obtained. | Optimizing our efforts based on the data obtained. | Optimizing our efforts based on the data obtained. | Optimizing our efforts based on the data obtained. | Optimizing our efforts based on the data obtained. | Optimizing our efforts based on the data obtained. | Optimizing our efforts based on the data obtained. | Optimizing our efforts based on the data obtained. |
| 4 | Support content, volume, and channels are managed using clear numerical values or quantities. | Support content, volume, and channels are managed using clear numerical values or quantities. | Vulnerability status is managed with clear numerical values or quantities. | Team identification status is managed with clear numerical values or quantities. | Incivility status is managed with clear numerical values or quantities. | Incivility status is managed with clear numerical values or quantities. | Relationship status is managed with clear numerical values or quantities. | Relationship status is managed with clear numerical values or quantities. | The level of understanding and implementation of accountability is managed using clear numerical values and metrics. | The coach's coaching philosophy and actions are managed using clear numerical values and quantities. | Coaches' leadership is managed using clear metrics and quantitative data. | Conflict management ability and initiatives are managed using clear numerical values and quantities. | Openness and initiatives are managed using clear numerical values and quantities. |
| 3 | Support content and channels are organized. | Support content and channels are organized. | The perspectives for identifying vulnerabilities have been organized. | A system is in place to explain, preserve, and improve team identity. | Methods for addressing incivility are organized. | Methods for addressing incivility are organized. | Factors and approaches for building good relationships are organized. | Factors and approaches for building good relationships are organized. | A system is in place to explain, maintain, and improve accountability. | A process is established that includes obtaining objective feedback regarding the coach's coaching philosophy and actions. | A process is established to clarify the coach's leadership and promote understanding from those around them. | The process for developing members' conflict management ability is systematized. | The process for developing members' Openness is systematized. |
| 2 | Understanding what kind of support is being provided and how it is being delivered. | Understanding what kind of support is being provided and how it is being delivered. | Collecting of vulnerability cases. | Team identity is deeply ingrained within the team. | Understanding what incivility is occurring and how it is occurring. | Understanding what incivility is occurring and how it is occurring. | Understanding how good relationships are built. | Understanding how good relationships are built. | Accountability is deeply ingrained within the team. | The coach's coaching philosophy and actions are being conveyed to the members. | The coach's leadership is being conveyed to the members. | The reasons and components for high conflict management ability are clearly defined. | The reasons and components for high Openness are clearly defined. |
| 1 | Understanding what kind of support is provided. | Understanding what kind of support is provided. | The concept of vulnerability has become a common language within the team. | Team identity has been articulated among some members. | Understand what actions constitute incivility. | Understand what actions constitute incivility. | Understanding the good and bad interpersonal relationships within the team. | Understanding the good and bad interpersonal relationships within the team. | Accountability is articulated. | The coach's coaching philosophy and actions are articulated. | The coach's leadership is articulated | Members with high conflict management ability can be identified, and their characteristics can be articulated. | Members with high Openness can be identified, and their characteristics can be articulated. |

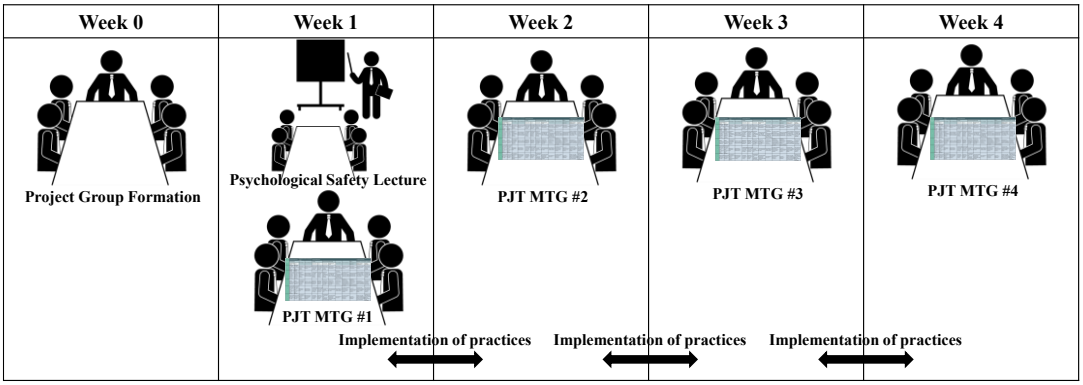


Figure 1: Overall Schedule for the Team Development Program

To operate the PS-CMM, we defined a use case: 1) a psychological safety lecture; 2) team formation; and 3) weekly meetings (Figure 1). At the first meeting, we used a causal loop diagram (CLD) to select focus KPAs. CLD, a system dynamics tool, visualizes feedback loops [17]. Mapping relationships among the 13 KPAs enabled the team to prioritize KPAs. The lecture and team formation met Requirement 2, while regular meetings met Requirement 1. Additionally, the PS-CMM and the first author's facilitation satisfied Requirement 4. Most activities used online tools like Zoom, Google Spreadsheets, and Miro.

# 3 Evaluation Method

To evaluate the effectiveness of the PS-CMM, a four-week control period was established prior to the four-week program intervention period (experimental period), enabling pre- and post-intervention score comparisons within the same target teams. Note that the start of the control period is designated as Time 1, the end of the control period and the start of the experimental period as Time 2, and the end of the experimental period as Time 3. Furthermore, a group

using a Prototype-PS-CMM was established as the comparison group [18]. The Prototype-PS-CMM used in the comparison group did not have key process areas specialized in the sports domain. Instead, it organizes the antecedents of psychological safety in non-sports fields such as industry and healthcare. The Prototype-PS-CMM users were not project team members; they were exclusively used by sports team coaches. Moreover, the comparison group only had coaches using the Prototype-PS-CMM consider and implement practices aimed at improving psychological safety. In addition, an untreated group was also established as a control group. This study employed a mixed-methods approach as a method for evaluating program effectiveness. Quantitative questionnaires regarding the team's perception of psychological safety were administered at three time points. At time 3, semi-structured interviews were conducted with randomly selected members from the experimental group.

## 3.1 Participants

The evaluated teams consisted of Japanese male student sports teams. These teams are typically characterized by strong top-down decision-making, which makes effective knowledge management difficult. Therefore, if the effectiveness of PS-CMM can be demonstrated in such student sports teams—where knowledge management is required but difficult to implement in practice—it would indicate the potential applicability of PS-CMM to a wider range of teams. The experimental groups consisted of a high school basketball team (43 members) and a university handball team (24 members). The comparison group consisted of a university handball team (14 members). The control groups were the university basketball team (33 members) and high school baseball team (73 members). The control period was from February to March 2025, and the experimental period was from March to April. February to April 2025 is the off-season for Japanese student sports, during which no official matches are held. It was confirmed for all target teams that no official matches took place during this period, no team member changes occurred, and the first-year students who joined in April had not yet joined the teams.

## 3.2 Measures in Quantitative Analysis

Two scales were used to survey psychological safety quantitatively. First, the Japanese version of the Team Psychological Safety Scale (TPS) developed by Edmondson (1999) [2] (Cronbach's $\alpha = .591$ — $.716$) [19], which is widely used to assess perceptions of TPS. The second was the Japanese version of the Psychological Safety for Mental Health (SPSI) by Rice et al. (2022) [20], which was used to assess perceptions of psychological safety related to mental health, specifically within a sports environment (Cronbach's $\alpha = .801$ — $.819$) [21]. The TPS was rated on a 7-point scale ranging from “strongly agree” to “strongly disagree,” while the SPSI was rated on a 5-point scale ranging from “strongly agree” to “strongly disagree.”

## 3.3 Questions for Qualitative Analysis

Among the respondents in the experimental group who answered at all three time points, six were randomly selected. The lead author conducted semi-structured interviews using the online tool Zoom. The questions covered changes in the team atmosphere, memorable events that occurred, and personal mental states during the eight-week period from the start of the control period to the end of the experimental period.

## 3.4 Data Analysis

For quantitative analysis, we used data from participants who completed all three waves: experimental (n=35; 52.2%), comparison (n=7; 50.0%), and control (n=84; 79.2%). We ran repeated-measures ANOVAs. Mauchly's test assessed sphericity, with Greenhouse–Geisser corrections applied when violated. Bonferroni post-hoc analysis identified the time points (Time 1, Time 2, and Time 3) that differed significantly. The control period was Time 1→Time 2 and the experimental period was Time 2→Time 3. For qualitative analysis, we employed the Grounded Theory Approach (GTA) [22] to organize (a) individual processes (personal state changes over eight weeks) and (b) team processes (team-level changes). The GTA advances the theory from data by specifying the mechanisms by which the observed phenomena arise [22]. Because the GTA extracts change mechanisms and process dynamics from empirical material, it is well suited for capturing the psychological changes induced by interventions [23]. Accordingly, we judged the GTA as the most appropriate method to systematize the change process within the experimental group's team context across both the control and experimental periods, which was central to this study.

## 3.5 Ethical Considerations

This study was approved by the Graduate School of System Design and Management at Keio University. Before data collection, participants received explanations about data handling and rights. Participation was voluntary and required informed consent. Anonymity was protected by ID numbers with strict safeguards. For interviews, we explained that only the first author would access data and no identifiable information would be collected. Participants could request data deletion anytime.

Table 4: Results of Descriptive Statistics

| Variables | Period | Minimum | | | Maximum | | | Mean | | | Standard deviation | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | E-Group | Com-Group | Con-Group | E-Group | Com-Group | Con-Group | E-Group | Com-Group | Con-Group | E-Group | Com-Group | Con-Group |
| Team Psychological Safety (TPS) | Time 1 | 3.29 | 4.86 | 3.43 | 6.86 | 6.14 | 6.57 | 5.12 | 5.45 | 5.07 | 0.67 | 0.46 | 0.70 |
| | Time 2 | 3.71 | 4.29 | 2.43 | 6.14 | 6.29 | 6.86 | 4.89 | 5.35 | 5.15 | 0.66 | 0.78 | 0.75 |
| | Time 3 | 2.86 | 4.71 | 3.00 | 6.71 | 6.57 | 7.00 | 5.04 | 5.76 | 5.11 | 0.81 | 0.78 | 0.85 |
| Psychological Safety for Mental Health (SPSI) | Time 1 | 2.09 | 2.55 | 2.00 | 4.55 | 4.18 | 5.00 | 3.01 | 3.22 | 3.39 | 0.55 | 0.54 | 0.59 |
| | Time 2 | 2.00 | 2.64 | 2.45 | 4.64 | 4.18 | 4.91 | 3.02 | 3.42 | 3.54 | 0.57 | 0.59 | 0.52 |
| | Time 3 | 2.00 | 3.09 | 2.09 | 4.64 | 4.45 | 5.00 | 3.36 | 3.68 | 3.53 | 0.59 | 0.52 | 0.59 |

*Note:* E-Group = Experimental Group, Com-Group = Comparison Group, Con-Group = Control Group

Table 5: Results of Repeated-Measures ANOVA

| Variables | Group | Mean | | | *p-value* | | |
|---|---|---|---|---|---|---|---|
| | | Time 1 | Time 2 | Time 3 | Time 1 - Time 2 | Time 2 - Time 3 | Time 1 - Time 3 |
| Team Psychological Safety (TPS) | Experime | 5.12 | 4.89 | 5.04 | 0.016 | 0.547 | 1 |
| | Comparis | 5.45 | 5.35 | 5.76 | 1 | 0.291 | 0.739 |
| | Control | 5.07 | 5.15 | 5.11 | 0.4 | 1 | 1 |
| Psychological Safety for Mental Health (SPSI) | Experime | 3.01 | 3.02 | 3.36 | 1 | <.001 | <.001 |
| | Comparis | 3.22 | 3.42 | 3.68 | 0.831 | 0.37 | 0.174 |
| | Control | 3.39 | 3.54 | 3.53 | 0.003 | 1 | 0.031 |

# 4 Evaluation Results

## 4.1 Results of Quantitative Analysis (Repeated-Measures ANOVA)

Table 4 (descriptive) shows that TPS exceeded the 4-point midpoint and SPSI exceeded the 3-point midpoint across all groups and time points, indicating no generally low levels for either measure. Table 5 (repeated-measures ANOVA) indicates that for TPS, only the experimental group showed a significant overall time effect (Wilks' $\lambda = .787$, $F(2,33) = 4.47$, $p = .019$, partial $\eta^2 = .213$). However, a significant change was observed during the control period ($p = .016$, 95% CI [0.034, 0.423]), but not during the experimental period. For SPSI, significant time effects emerged in both the experimental group (Wilks' $\lambda = .519$, $F(2,33) = 15.315$, $p < .001$, partial $\eta^2 = .481$) and the control group (Wilks' $\lambda = .870$, $F(2,82) = 6.14$, $p = .003$, partial $\eta^2 = .130$). Post-hoc comparisons showed a significant improvement in the experimental group during the experimental period ($p < .001$, 95% CI [−0.543, −0.148]). The control group improved during the control period ($p = .003$, 95% CI [−0.261, −0.044]).

## 4.2 Results of Qualitative Analysis (GTA)

Next, we present the results of GTA. Owing to space constraints, we refrain from including the category association diagram but provide the storyline. Here, 【】 denotes the central category, 《》 denotes a category, "" denotes a property, and '' denotes a dimension.

Three category-related diagrams of individual and team processes during the control period were created, and one related to psychological safety (PS) is shown. Regarding the fear of 《observing or missing practice owing to injury or illness,》 if such absences are frequent and "injury severity" is 'low,' increased communication—such as 《consulting teammates or engaging in casual conversation》—stimulates the 《hunger for competition.》 However, when "injury severity" is 'high,' limited communication causes a 《coaches' communication imbalance》 and an intensified 《sense of distance from the coach,》 triggering a strong 《fear of absence.》 This fear, rooted in anxiety about how the coach perceives absences, has led some athletes to continue participating even when injured or unwell. Thus, during the control period, weak coach–athlete relationships amplified the fear of absence.

Seven category-related diagrams were produced during the experimental period; one re-

lated to PS is shown here. Strengthening《coaches' listening posture》resulted in more coach questions and less hesitation to speak up, leading to a【reduction in the psychological barrier to communicating with coaches】and an increased "amount of communication with coaches." Athletes 《able to objectively view the sport due to injury-related absence》 saw their 《coaches frequently talking with team members,》reinforcing an attitude of communication through modeling, increasing the 《amount of communication with coaches.》

When facing《illness,》those recalling《past absence experiences》initially viewed absence negatively. Yet, as 【understanding of the coach's perspective】 deepened, empathy grew, creating safety that 《it's okay to be absent or observed,》 leading to 《improvements in low self-stigma.》

Finally, the 《establishment of a common language for psychological safety》 increased its "penetration level," producing【improved communication among core team members.】The greater frequency of "core members initiating conversations" enabled the 《sharing of emotions with teammates.》 Progress in 《building relationships through a deeper mutual understanding》 further promotes 《easier communication among team members.》

In summary, improvements in PS were driven by three dynamics: (1) enhanced listening attitudes among coaches, (2) increased relationship-adjustment behaviors among core members, and (3) reduced stigma surrounding absence or injury.

## 5 Discussions

The quantitative results showed that only the experimental group that implemented the PS-CMM demonstrated a statistically significant improvement in SPSI before and after the intervention. This improvement is linked to the Key Process Area (KPA) the group addressed—member–coach relationship, team identification, and athlete openness. Both teams emphasized enhancing the member–coach relationship by progressing from Maturity Level 1 to Level 2, primarily through open communication about the coach's principles, expectations, and role. This effort deepened mutual understanding, reduced the fear of revealing personal vulnerabilities, especially concerning mental health, and strengthened trust. Qualitative analysis (GTA) indicated that this reduced fear of withdrawal owing to injury or illness fostered a greater sense of security, allowing athletes to rest confidently for recovery. In addition, improved listening behaviors by coaches and increased communication among core members lowered psychological barriers to emotional expression and opinion sharing. Although TPS did not show significant quantitative improvement, the qualitative results suggest a potential for future growth. The short four-week period likely limited visible team-level changes, as the TPS reflects collective perceptions. In contrast, the SPSI captures individual-level perceptions related to mental health, making it more sensitive to short-term interventions. The present intervention targeted student sports teams—groups that likely represent one of the most challenging contexts for improving psychological safety, given their high uncertainty and the strong influence of top-down decision-making. Using these teams, we examined the effectiveness of the PS-CMM. Because the framework enables teams to select KPAs that align with their specific context and to engage in continuous approaches to enhancing psychological safety, it is possible that PS-CMM could also be

adapted for use in non-sport teams.

This study represents the first attempt to apply a process-maturity perspective to psychological safety (PS) research, demonstrating the utility of the PS-CMM as a knowledge-driven model. The theoretical contribution lies in structuring previously unorganized requirements for PS interventions, developing an intervention method aligned with these requirements, and designing the PS-CMM. This suggests that the framework provides a means of transforming efforts to enhance psychological safety from tacit experience-based practices to standardized and shareable ones, thereby contributing to the advancement of practical interventions in knowledge management theory. From a practical standpoint, despite the short intervention period compared with previous studies, the program produced measurable effects [15–18]. Quantitatively, SPSI improved significantly, and qualitatively, signs of enhanced PS were evident. This suggests that the PS-CMM successfully addressed the antecedent factors suited to the team's specific context, which is a key requirement for effective interventions identified in prior research. Moreover, the model's iterative and continuous processes, rather than sporadic activities, likely contributed to fostering PS. Although the KPAs of the PS-CMM were customized for sports teams, the framework may also be adaptable to other team contexts and contribute more broadly to improvements in psychological safety. Through the continuous use of the PS-CMM, improvements in psychological safety are expected to lead to enhancements in team performance, such as teamwork, as demonstrated in previous studies, as well as to improvements in mental health outcomes, including reductions in burnout.

However, this study had several limitations. First, the experimental group consisted of two male student sports teams, and only one team served as the comparison group; therefore, the limited number of participating teams restricts the generalizability of the findings. Second, a short intervention period (four weeks) may not capture long-term or team-level changes. Third, the relatively low reliability of TPS may have hindered effect detection, a problem noted in earlier sports research (e.g., Fransen et al., 2020). Fourth, no longitudinal follow-up was conducted to assess sustainability; therefore, the medium- to long-term effects of the PS-CMM require further consideration.

## 6 Conclusion and Future Research Topics

This study reviewed prior research to develop a psychological safety (PS) intervention method, extracted its requirements, and implemented a Psychological Safety Capability Maturity Model (PS-CMM). The quantitative analysis results showed that only the SPSI in the experimental group demonstrated a statistically significant improvement before and after the PS-CMM. The qualitative analysis results confirmed an increase in perceived PS centered on relationships with coaches. In this study, we demonstrate the practical efficacy of the newly proposed PS-CMM and contribute to the development of an intervention model that advances the design, evaluation, and improvement of PS in a knowledge-driven manner. Furthermore, as a design approach to promote knowledge sharing and team learning, the PS-CMM demonstrates new application possibilities for team development in the fields of e-services and knowledge management.

Moving forward, it will be necessary to carefully examine what changes occur within teams by expanding the number of target teams to confirm the consistency of the findings obtained in this study and by implementing the intervention not just for four weeks but over the me-dium to long term. Furthermore, we must carefully examine which of the 13 KPAs, when targeted, increases TPS and SPSI, as well as the impact of individual KPAs. It is also nec-essary to implement programs for teams outside the sports domain.

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