Self-reflection support system for team sports based on reflection perspective classification

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Abstract. The purpose of this study is to support team sport players in their post-match reflections. Reflecting on the match and recognizing points for improvement is important for preventing repeated mistakes and improving the accuracy of decision-making during play. However, in team sports, players need to be aware not only of their individual actions, but also of the situation of the team, such as their positioning according to the development of the match and cooperation between players. And there are many items to consider, and it is not easy to systematically verbalize points for reflection. Therefore, we attempted to solve this problem by developing a system that categorizes the content of reflection into four types and helps participants verbalize their reflections for each item. To verify the usefulness of the proposed system, we focused on soccer, a sport in which players' movements tend to be complex, and observed 12 experienced soccer players as they used the system to reflect on their matches. The results suggested that presenting reflection perspectives contributes to concretizing the content of reflection and promoting reflection from multiple perspectives.

Keywords: Self-reflection · Team sport · Verbalization of reflection · Framework · Reflection type.

1 Introduction

In team sports, players are required to have the ability to instantly assess the situation in the flow of the match and to quickly decide on and execute the appropriate action. Murakawa et al.[6] point out that skilled players tend to be better at making split-second decisions than unskilled players, and that there is a possibility that players with strong decision-making abilities possess excellent underlying pattern perception. To acquire such decision-making skills and apply them effectively in practice, it is necessary to reflect on momentary decisions and take the time to analyze them. In this process, it becomes important to review the cognitive processes behind decision-making, identify personal challenges, and derive specific areas for improvement. Post-match reflection has been recommended as one of the ways to achieve this[3]. Self-reflection is said to not only improve the accuracy of decision-making, broaden playing options, and cultivate superior decision-making skills, but also to increase motivation to compete and improve metacognitive abilities[1][7]. In this way, post-match reflection

is not just about reflecting on the past, but is recognized as an effective way of improving momentary decision-making by encouraging the diversification of the thought processes and options that lead to those decisions.

At present, common methods of reflection include verbal reviews while watching a match video or keeping a sports journal. However, in team sports, where complex tactics and rapid changes in the situation occur, it is difficult for players to accurately grasp all the relevant factors, such as the movements of other players or tactical cooperation, using these methods alone. Additionally, because it is often hard to verbalize these complex situations, existing reflection methods can be a burden on players.

Therefore, the goal of this study is to systematize the act of post-match reflection and to build a system that makes it easier for players to verbalize their thoughts. In this paper, we propose a method of classifying the elements that players should consider when reflecting on their actions and provide a framework to promote reflection from each perspective. This method enables players to analyze themselves from multiple perspectives and broaden their reflection. Consequently, it promotes a deeper understanding of their own actions and encourages specific reflection entries, thereby aiming to enhance the quality of their self-assessment. This paper examines whether the proposed framework, based on our classification of reflection types, promotes multifaceted and specific reflection.

2 Related work

In this chapter, we introduce research into the limitations of current situation reflection and methods for supporting reflection, and clarify the position of this research. Downham et al.[2] analyzed the depth of reflection practice of high-performance sports coaches by classifying them into multiple stages. The results revealed that many coaches remain at the early stages of "descriptive thinking" which involves verbalizing "what happened during the match" and "evaluative thinking" which involves determining "what went well." This shows that even coaches have difficulty engaging in deep self-reflection without structural support, and suggests that athletes need even more support.

In the field of learning science, Matheson et al.[5] revealed that while guided reflection is effective in encouraging focus on a specific topic and improving metacognition, an unguided environment is less restrictive and allows for more diverse and richer reflections. From this knowledge, we can consider that for those who do not fully understand how to reflect or who have difficulty properly verbalizing their thoughts, guided reflection may be more effective.

In recent years, within the field of sports, an approach in which athletes themselves take the lead in analysis has been attracting attention in support of reflection. Hjort et al.[4] investigated the impact on players of "Player Universe," an analytics platform enabling users to tag their own match footage. However, the process of translating analysis results into concrete language and engaging

in deep introspection relies heavily on external intervention, such as feedback and questions from coaches.

So, we can consider that there is insufficient structure in place for athletes to autonomously articulate their own thoughts. Thus, while Player Universe has demonstrated its effectiveness in encouraging player-led reflection, the process of verbalizing the knowledge gained to a level where it can be put into practice is thought to depend on the coach's teaching ability and the player's individual thinking ability. Thus, to encourage players who lack sufficient cognitive capacity and find verbal expression difficult to engage in deep self-reflection, it is important to provide a structured framework for reflection, along with guides such as perspectives and prompts. Based on the knowledge, we propose a framework that allows players to reflect on their own play from multiple perspectives and to concretely verbalize their thoughts in this study. Specifically, by classifying the elements to be considered during reflection and implementing a system that enables a systematic description of reflections based on each perspective, we support players—even those who do not habitually reflect or who struggle to verbalize their thoughts—in practicing multifaceted and concrete reflection.

3 Proposed method

This chapter examines issues arising at each stage of the post-match reflection process and organizes the functional requirements for the implemented review support system. The reflection process is explained below.

1. **Recalling and deciding on the scene after the match**
   First, players recall and decide on the memory of the scene they want to reflect.
2. **Taking stock of situation**
   By clearly organizing the background and circumstances of the play within the determined reflection scene, players can objectively and specifically grasp what happened and how the play was carried out.
3. **Verbalizing points of reflection and challenges**
   Players clarify the play that needs to be reflected upon, think about what went wrong and why it happened, and put it into words.
4. **Deciding on an approach to the challenges** Players think specifically about how they can improve the issues they have verbalized, and derive ways to utilize them in future plays.

In this study, we define stages (1) and (2) as the preparation stage, and stages (3) and (4) as the reflection writing stage. Below, we will organize the problems that arise at each stage, describe the mechanisms, and implement an interface for solving them.

3.1 The preparation stage

At stage 1, players identify plays that need improvement based on a match video and recall the situations in which they played. However, it is difficult for players

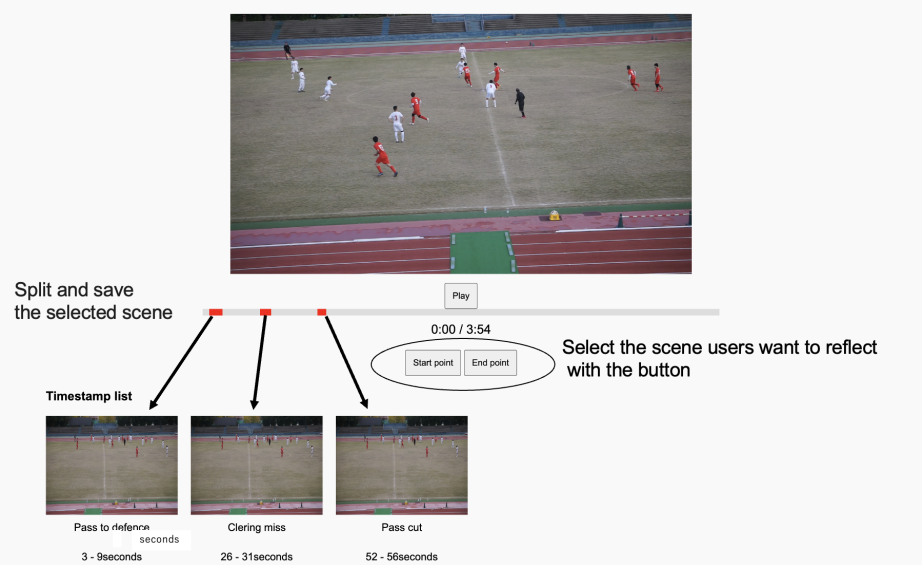

Fig. 1. Splitting function for reflection scenes.(Note: The video shown is for illustrative purposes and differs from the one used in the experiment.)

to memorize every play in a match. Therefore, when reflecting on a match, players often do so based on only a portion of the video they remember, and there is a concern that they may miss specific details of the play due to the vagueness of their memories. Therefore, it is burdensome because players must watch the entire video from the beginning, requiring significant time and effort to identify scenes where they conduct reflection. To resolve this problem, our system provides a mechanism to efficiently organize and record important plays and decisions, allowing for intuitive reflection. This feature is designed to reduce the burden of reflecting the entire match video by allowing users to segment and save individual scenes for reflection1.

At stage 2, players analyze the background and causes of their own mistakes within the scene to establish a foundation for verbalizing their reflections. However, when players analyze their own play after a match, there are numerous factors they must consider, particularly in defensive situations or when not in possession of the ball during attacks. Identifying areas for improvement in their positioning often takes considerable time. Thus, it is necessary to simultaneously observe the movements of other players and the ball, creating a burden as it takes time to grasp the overall picture. To solve this problem, our system provides a mechanism that visually and conceptually organizes key factors such as player positions and play selection, thereby enabling players to intuitively grasp the situation. This feature is designed to help players easily grasp the playing situation of a scene by efficiently organizing details that are difficult to perceive

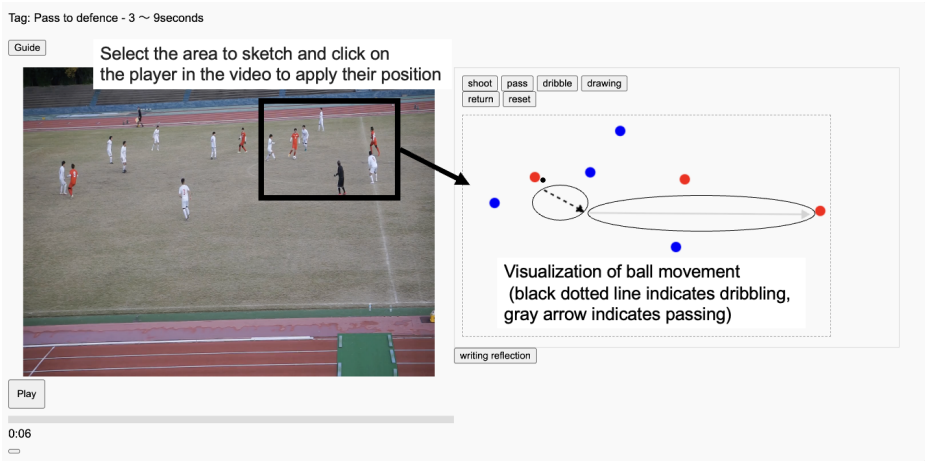

Fig. 2. Sketch function. (Note: The video material is for illustrative purposes.)

from the video alone2. To realize this mechanism, we created a sketch interface that visually records players' positions during matches and the flow of play.

3.2 The writing reflection stage

At stages 3 and 4, they verbalize and document reflections based on the information that they organized at stages 1 and 2. However, when verbalizing reflections, there is a risk that adopting a biased perspective may cause one to overlook the underlying causes and reasons for fundamental mistakes. For example, a player might focus solely on a technical error (e.g., poor footwork) while ignoring a more critical tactical issue (e.g., incorrect positioning before receiving the ball). Furthermore, when players write their reflection points without knowing how to properly articulate their reflections, there is a risk that the content of their reflections will become vague. As a result, it may not be possible to identify mistakes that need improvement, making it difficult to conduct effective reflection. To solve this problem, our system provides a mechanism that encourages players to analyze their own play from multiple perspectives and to write detailed, organized reflections. This prevents players from overlooking the fundamental issues they need to improve upon and attempts to make their reflection more concrete.

To realize this mechanism, we focused on soccer. Soccer is a sport where tactics have gained greater importance in recent years, and match situations have become more complex. Using reflection notes written by players from the author's team as a reference, we categorized the four reflection types: "Technical Reflection," "Physical Reflection," "Tactical Reflection," and "Mental Reflection." We defined that "Technical Reflection" is a mistake about a lack of player skills (e.g., trap error, dribbling error, shooting error). We defined that "Physical Reflection" is a mistake about the lack of physical ability of players (e.g., unable

to run the entire match, physically defeated, and lost the ball). We defined that "Tactical Reflection" is a mistake about a positioning error (e.g., should take inside position but took outside position when receiving the ball), cooperation error (e.g., ball lost because of differences in common understanding among teammates), and decision error (e.g., should dribble vertically but dribbled inside). We defined that "Mental Reflection" is a mistake about playing error due to psychological factors (e.g., played passively because of dwelling on mistakes and intimidated by the opponent). By having users select one of these four types using a checkbox and write down their reflections from each perspective, they can consider from multiple angles which of their own issues they should prioritize and clarify for improvement.

In addition to these, the system sets six reflection items: "Situation," "Reflection Points" "Causes," "Challenges," "Improvement Methods" and "Goal Setting"—and prompts users to write reflections for each item. "Situation" was defined as an item for organizing the plays and match situations a user faced and verbalizing the events occurring in those scenarios. "Reflection Points" were defined as an item for choosing which play error should be reflected and verbalized. "Causes" were defined as an item for analyzing and verbalizing the reasons and background that led to the play requiring reflection. "Challenges" were defined as an item for verbalizing the fundamental challenges that the player must resolve after clarifying the causes of plays requiring reflection. "Improvement Methods" was defined as an item for concretely verbalizing the approach to be taken in the future to resolve the "Challenges." "Goal Setting" was defined as an item for establishing achievable and specific goals for the next match and planning actions to achieve them. These reflection items are related to each other, and by filling them out in order from the top down, users can gradually reflect on their own play and clarify issues and improvement measures. First, by writing down the "Situation," you verbalize the specific context of the reflection scene, aiding subsequent reflection and analysis of causes. Next, write down the "Reflection Points" to identify which plays were problematic, then explore the reasons why those mistakes or issues occurred through the "Causes." Under "Challenges," based on the "Causes," list which areas require focused improvement, and under "Improvement Methods," think through specific approaches to address "Challenges," linking them to your mindset for future plays. Furthermore, under "Goal Setting," establish concrete and realistic goals based on the information outlined in the above items, defining the direction for self-improvement. In this way, by encouraging step-by-step reflective writing, we help organize thoughts and support the derivation of specific improvement points.

Also, based on these reflection items, specific prompts were set for each item to enable easy and effective verbalization. For example, regarding "Reflection Points," prompts such as "What do you think went wrong with your play? What aspects should have been improved in that situation?" are presented to help players conduct reflection clearly in the context of their play. Such comprehensive prompts make it difficult to deepen reflection based on specific perspectives, and different types of reflection require distinct modes of thinking. So,

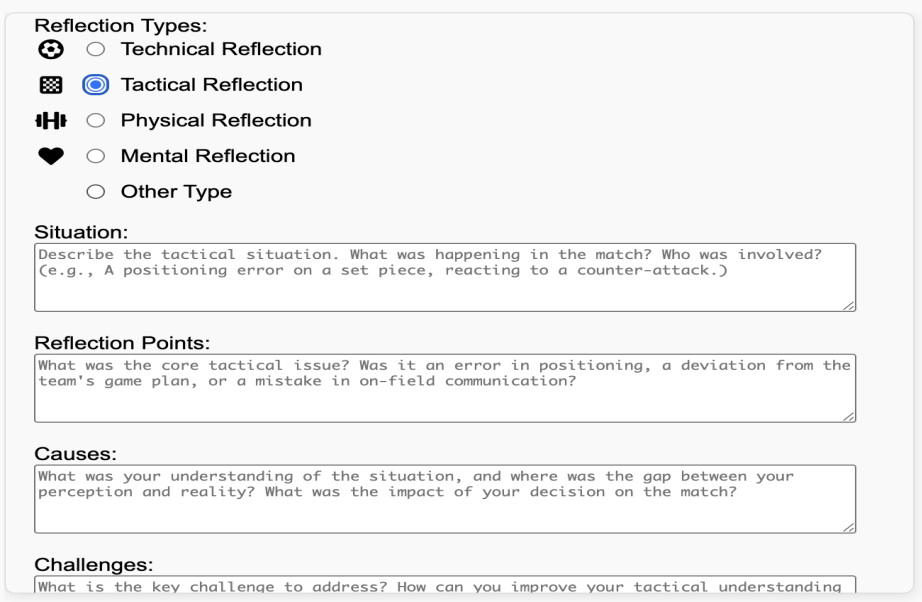

Fig. 3. The framework based on reflection types.

uniform prompts may prevent users from engaging in sufficiently deep reflection. Therefore, we modified the prompts appropriately for each reflection type. For example, regarding "Reflection Points" in "Technical Reflection," present a prompt such as: "Are these mistakes due to skill deficiencies (shooting accuracy, ball control, etc.)?" By changing prompts for each reflection type, users can conduct self-assessments within a more specific framework, enabling them to gain deeper insights into their own play and mentality. By creating and presenting a framework based on reflection types that combines these three mechanisms, we can improve the quality of users' reflections and provide systematic support that encourages individual growth3.

This system was primarily built using Python and was provided as a web application without device restrictions when an internet connection is available. In addition, the front-end user interface was built using HTML, CSS, and JavaScript to enable dynamic functionality. For video processing, we used the Moviepy library.[1]We used SQLite for database management and developed a system to efficiently store and manage players' reflections and video metadata.

[1] https://zulko.github.io/moviepy/

Table 1. Average character count per reflection (characters/number of reflections submitted) and increase ratio (free description/the proposed system)

	FD-first			System-first			ave
ID	1	2	3	4	5	6	
Free description	43.0	77.7	52.3	107.6	140.2	29.2	75.0
System	234.0	118.0	286.0	206.5	133.6	112.0	181.6
Ratio	5.4	1.5	5.4	1.9	0.9	3.8	3.1

4 The impact of the proposed system on reflection verbalization

This chapter analyzes how the proposed system influences the verbalization of reflection. We hypothesize that using the system makes reflection content more concrete and easier to verbalize, which we verify by comparing reflections written with and without the system.

4.1 Experimental procedure

Six participants with soccer experience were asked to write reflections. They were divided into two groups of three to control for order effects: the free description initiation group (FD-first group, writing in free description followed by the proposed system) and the proposed system initiation group (System-first group, writing in the proposed system followed by free description).

The procedure was as follows:

1. **Scene Selection:** Participants segmented scenes requiring reflection from a 1-minute, top-down view match video. To ensure objectivity and generality, we used videos of matches they had not played in.
2. **Situation Sketch:** Before writing, participants sketched the play situation.
3. **Writing Reflection:** Each group wrote reflections for 20 minutes under each condition (free description via Google Form and using the proposed system).
4. **Interview:** We conducted semi-structured interviews to qualitatively assess the system's usefulness.

4.2 Results and discussion

To evaluate the system's impact, we compared the number of characters and the time taken to write reflections between the two conditions. The results are shown in Table 1 and 2.

On average, using the proposed system increased the character count by 3.1 times and the writing time by 5.1 times compared to free description. The increase in character count suggests that the system encourages more detailed reflections, while the longer writing time implies deeper cognitive engagement. However, this also indicates a higher writing burden.

Table 2. Average time spent per reflection (seconds/number of reflections) and increase ratio (free description/the proposed system)

	FD-first			System-first			ave
ID	1	2	3	4	5	6	
Free description	114.5	110.0	174.3	120.6	145.5	51.4	119.3
System	1162.0	278.2	1323.0	414.0	142.2	332.5	608.6
Ratio	10.1	2.5	7.5	3.4	0.9	6.4	5.1

Regarding the order effect, the FD-first group showed a larger increase in character count (3.6 times) and time (6.9 times) compared to the System-first group (1.6 and 2.7 times, respectively). This suggests that using the system first may structure a user's thoughts, serving as a guide for subsequent free description.

A qualitative analysis of participant logs supports these quantitative findings. For instance, id1 (FD-first) wrote a brief, general comment in free text but provided a detailed analysis of causes and future actions using the proposed system. This suggests the proposed system helps concretize reflections. Conversely, id5 (System-first) stated that using the proposed system first helped organize his thoughts, allowing for more efficient and structured free description afterward. Interviews revealed that while the proposed system's structure was helpful for organizing thoughts, some reflection items felt redundant or the prompts were too detailed, indicating a need for design improvements.

5 The impact of prompts on verbalization of reflection

This chapter analyzes how prompt design affects the verbalization of reflections. We compare variable prompts, which change based on the reflection type (used in the previous experiment), with fixed prompts, which remain the same regardless of the type.

5.1 Experimental procedure

We conducted an experiment with six new participants, following the same procedure as in Chapter 4, but replacing the variable prompts with fixed ones. The fixed prompts were:

- **[Situation]** What was the situation?
- **[Reflection Points]** What went wrong with your play?
- **[Causes]** What do you think caused the mistake?
- **[Challenges]** What specific actions do you need to improve?
- **[Improvement Methods]** How can you avoid making the same mistake?
- **[Goal Setting]** What goals should you set for similar situations?

Table 3. Average character count per reflection and increase ratio

	Fixed/FD-first			Fixed/System-first			Ave.
ID	7	8	9	10	11	12	
Free description	32.2	27.6	38.6	67.4	294.0	94.2	92.3
System	155.5	163.0	128	112.0	435.0	138.0	188.5
Ratio	4.8	5.9	3.3	1.6	1.4	1.4	3.1

Table 4. Average time spent per reflection and increase ratio

	Fixed/FD-first			Fixed/System-first			Ave.
ID	7	8	9	10	11	12	
Free description	64.8	29.6	129.0	152.0	337.0	93.0	134.2
System	383.5	270.0	383.5	313.0	694.0	168.7	368.7
Ratio	5.9	9.1	2.9	2.0	2.0	1.8	3.9

5.2 Result and discussion

We compared the results from the fixed prompt experiment with those from the variable prompt experiment (Chapter 4). The quantitative results for both conditions are summarized in Table 3 and 4.

In the FD-first groups, the variable prompt group showed a smaller increase in character count (3.6x) but a much larger increase in writing time (6.9x) compared to the fixed prompt group (4.5x and 4.6x, respectively). This suggests that variable prompts may encourage deeper thinking and more specific content, even if the total volume of text is not as large.

Qualitative analysis supports this. For example, when comparing id3 (variable prompt) and id8 (fixed prompt), who reflected on similar tactical situations, id3 wrote a more detailed reflection with specific numerical goals (e.g., "Shake head more than 20 times per game"), but took significantly longer (1323 seconds vs. 270 seconds). This indicates variable prompts can improve reflection quality at the cost of efficiency. Interviews also revealed that while helpful, the detailed nature of variable prompts could be overwhelming for some users, increasing their cognitive load.

These results suggest that while variable prompts can lead to more in-depth reflection, their design needs to be optimized to reduce user burden.

6 Verification of the reflection types' validity

This chapter verifies the validity of the reflection types. To clarify whether the reflection types are valid, the reflection sentences written by participants in the experiments conducted in Chapters 4 and 5 were vectorized using Sentence-BERT[2], and hierarchical clustering was performed to extract words contained in the reflection sentences classified into each cluster to investigate the criteria

[2] https://huggingface.co/sonoisa/sentence-bert-base-ja-mean-tokens-v2

used for classification. As a preprocessing step of clustering, we deleted any references to "Situation" in the reflection sentences because there was a risk that if participants clipped the same scene, the sentences written in "Situation" would be similar and could be clustered based on that. Table 5 shows the correspondence between the reflection types selected by the participants and the sentences classified by the clustering results.

The number of clusters with the highest silhouette score was nine. To investigate this factor, we examine the consistency between the reflection types selected by participants and the clustering results, as well as the words contained in each cluster.

In Cluster 1, the types selected by participants were classified as three "Technical Reflections," four "Tactical Reflections," and three "Mental Reflections." It was confirmed that these included words such as "position," "decision," and "positioning," suggesting that these types of reflections were about players' decisions and play choices when in possession of the ball, and bad positioning.

In Cluster 2, the types selected by participants were classified as three "Technical Reflections." It was confirmed that the words "accuracy," "weak foot," and "skill" were included, suggesting a reference to a lack of skills in handling the ball during attacks, such as kicking and ball control.

In Clusters 3 and 9, the types selected by participants were classified as six "Tactical Reflections." It was confirmed that the words included "defensive line," "organization," and "defensive awareness," and it is thought that these were classified as reflections on defense involving multiple players, such as not following team rules and not sharing tactics properly.

In Cluster 4, the types selected by participants were classified as one "Tactical Reflection" and one "Mental Reflection." It was confirmed that the words "calling out" and "communication" were included, and it is thought that the reflections on communication and calling out within the team, such as other teammates needing to give instructions to a player who has made a mistake, were classified.

In Clusters 5, 6 and 7, the types selected by participants were classified as four "Technical Reflections" and three "Tactical Reflections." It was confirmed that the words included "passing routes," "how to press," and "defensive techniques," and reflections on individual defensive techniques, such as how to cut off passing routes and the timing to press opposing players, were classified.

In Cluster 8, the types selected by participants were classified as one "Physical Reflection." The inclusion of words such as "stamina," "tiredness," and "running" was confirmed, and reflections on a lack of physical ability were classified.

In the interviews, the type of reflection on "players' decision" chosen by each participant varied, with opinions such as "I choose between 'Technical Reflection' or 'Tactical Reflection' based on whether it is a team or individual." These findings suggest that by designing a hierarchical reflection type, with team or individual and attack or defense perspectives as options at the top level of the defined reflection types, users may be able to write reflections in a more multifaceted and detailed way.

Table 5. The result of clustering

cluster(C)	C1	C2	C3	C4	C5	C6	C7	C8	C9
Technical Reflection	3	3	0	0	0	2	2	0	0
Physical Reflection	0	0	0	0	0	0	0	1	0
Tactical Reflection	4	0	4	1	2	0	1	0	2
Mental Reflection	3	0	0	1	0	0	0	0	0

7 Conclusion

In this paper, we classified reflection content into several types and examined the usefulness of a framework comprising reflection items and prompts based on this classification. The verification results indicated increases in both the number of characters and writing time, suggesting that the framework encouraged deeper thinking during reflection writing and made the content more concrete, even when reflecting on videos of matches played by others.

As a next step, the proposed framework is being considered for improvement to make it easier to use and more effective. The analysis from this study revealed several avenues for refining the framework design. Our clustering analysis and participant feedback suggested that the four reflection types, while a useful starting point, require refinement. A potential redesign could involve hierarchization, such as adding a higher-level classification of 'team' or 'individual' perspectives above the current four types, to provide clearer guidance. Furthermore, as noted by some participants, the detailed nature of the variable prompts may increase cognitive load. These findings highlight the need to refine the prompts and further investigate the subjective user experience.

The system developed in this study can also be used to collect users' thought processes in a structured format by integrating objective data, such as the positions of players in the video and play choices, with subjective data, such as reflection types and reflective text for each item. The sketching function not only records the actual playing situation but also visualizes and records the ideal positioning and alternative play options based on the players' thinking, allowing data to be collected for comparative analysis between actual play and the players' tactical decisions. Therefore, by taking an approach that focuses on the gap that exists between objective playing data and the players' thought processes, it is expected that deeper reflection will be promoted.

Taking these points into consideration, we aim to optimize AI-based support for retrospective verbalization by utilizing the data collection infrastructure constructed in this study. Specifically, a significant future direction is to use the collected structured data to build a large language model (LLM) that enables interactive reflection tailored to players' abilities and thought patterns. To realize this advanced AI support and ensure its robustness, our current exploratory findings must be validated and expanded. Therefore, future work will involve validating the improved framework with a larger and more diverse population, including novices and players from different team sports, and conducting long-

term assessments of its impact on performance. This expansion is essential not only to verify the generalizability of our approach but also to acquire the rich dataset needed to fuel the next generation of personalized reflection support.

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