Demonstrating Multimodal Dandelions: Interactive Playback for Teachers' Multi-Granularity Reflection on Spatial Pedagogical Behaviors

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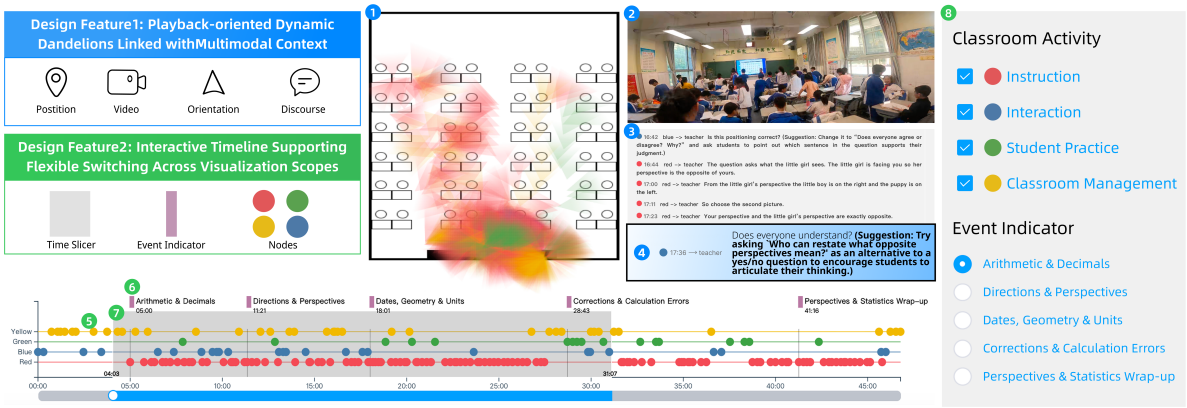

Figure 1: Design features and design components of Multimodal Dandelions. The design components include: (1) playback-oriented dynamic Dandelions that visualize teachers' positions and body orientations, (2) a discourse transcription and suggestion panel, (3) a video viewport, (4) LLM-generated suggestions, (5) a time slicer, (6) event indicators, (7) nodes, and (8) a filtering panel.

Abstract

Teachers' spatial pedagogical behaviors are central to classroom practice, but they are often transient and difficult to reflect on systematically. We present Multimodal Dandelions, a multimodal dashboard that supports teachers' reflection on spatial pedagogical behaviors across different temporal granularities. The system introduces replayable Dandelions that dynamically visualize teachers' position and orientation data and reveal how spatial patterns accumulate and change over time. These visualizations are synchronized with classroom video and discourse to provide contextual support for interpreting teachers' spatial behaviors. Interactive components, including a time slicer, nodes, and event indicators, enable teachers to switch between whole-lesson overviews, classroom activity types, key events, and individual transcript lines.

CCS Concepts

• **Human-centered computing** → **Information visualization**.

Keywords

Teacher Reflection, Spatial Pedagogy, Multimodal Learning Analytics, Classroom Analytics, Interactive Dashboard

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1 INTRODUCTION & BACKGROUND

Teachers' spatial pedagogical behaviors, including their positioning, movement, orientation, proximity, and use of classroom space, constitute an important part of classroom teaching practice. Through these spatial behaviors, teachers organize classroom interactions, distribute instructional attention, and support student learning [11]. However, such behaviors are often ephemeral, making it difficult for teachers to recall and systematically reflect on their spatial teaching patterns, especially when relying only on memory or time-consuming video review [10].

Recent advances in sensing technologies, computer vision, and multimodal learning analytics have opened up new opportunities for capturing and visualizing teachers' spatial pedagogical behaviors. For example, Martinez-Maldonado [12] and ClassBeacons [3] used teachers' positioning data to show their proximity to student groups, while Classroom Dandelions [8] further incorporated orientation data based on F-formation theory. However, position and orientation data alone provide limited context for interpretation. Without additional sources such as discourse and video, teachers may over-interpret spatial patterns or drawing pedagogical meanings that are not fully grounded in the classroom context [2, 8, 14]. Existing spatial reflection systems also have room for improvement in dynamic representation and interaction. Many systems rely on static visualizations, which can make it difficult to see how teachers' spatial patterns emerge and shift over time [9]. Interaction Geography Slicer [15] links classroom video and teacher–student discourse with replayable movement trajectories, but does not incorporate orientation data, which is important for inferring teachers' spatial attention and F-formations. Prior systems have also supported selecting time intervals or filtering data by activities and roles [1, 16]. Yet few studies have explored how to automatically structure a lesson across different temporal granularities, even though teachers often need to review classroom practices from broader to more local scopes.

We demonstrate Multimodal Dandelions, a replayable dashboard that synchronizes teachers' position, orientation, video, and discourse data to support multi-granularity reflection on spatial pedagogical behaviors. The system links dynamic spatial visualizations with multimodal classroom context and organizes them through interactive temporal components. First, Multimodal Dandelions integrates teachers' position and orientation data with classroom video and discourse, providing richer contextual grounding for interpreting spatial F-formations. Second, it enriches playback content by aggregating teachers' position and orientation data and presenting accumulated changes in orientation-based proxies of teachers' attentional focus over time. Third, it structures a lesson into multiple temporal perspectives, including classroom activities, teaching events, and individual transcript lines. Interactive components, including a time slicer, nodes, and event indicators, support flexible switching across these perspectives.

We conducted a user study with eight teachers to explore how Multimodal Dandelions supports reflection. The findings suggest that the system helped teachers move from whole-lesson overviews to local classroom moments, interpret spatial behaviors through linked multimodal evidence, and identify opportunities for improving future teaching practices. The study also showed good usability and surfaced teachers' expectations for future system extensions.

2 MULTIMODAL DANDELIONS

2.1 Design Features

Multimodal Dandelions is built around two primary design features (DFs), each realized through several interactive components:

DF1: Playback-oriented Dynamic Dandelions Linked with Multimodal Classroom Context. It consists of three components. **(1)** ***Playback-oriented dynamic Dandelions*** (Figure 1(1)). This component combines teachers' positioning and orientation data within a unified visual representation. A detailed introduction is provided in Appendix A. Below the Dandelions, playback controls are provided, including play, pause, speed adjustment, fast-forward, and rewind. When the playback runs at 1x speed, one Dandelion is placed onto the classroom map every second. This reveals how teachers' locations and body orientations shift across the classroom space over time, offering an orientation-based proxy for changes in their attentional focus. **(2)** ***Discourse transcription and suggestion panel*** (Figure 1(2)). This panel shows timestamped transcriptions of teachers' discourse line by line and attaches LLM-generated suggestions to certain lines. To generate these suggestions, the LLM is prompted using principles drawn from Bloom's taxonomy [4] and Academically Productive Talk (APT) [13]. For instance, as shown in Figure 1(4), after the line "Does everyone understand?", the system appends a suggestion: "Try asking 'Who can restate what opposite perspectives mean?' as an alternative to a yes/no question to encourage students to articulate their thinking." **(3)** ***Video viewport*** (Figure 1(3)). The video viewport displays the classroom recording taken from the back of the room. During playback, the visualizations across these three components remain continuously synchronized via timestamps.

DF2: Interactive Timeline Supporting Flexible Switching Across Visualization Scopes. This second design feature is supported by three additional interactive components embedded in the timeline. **(4)** ***Time slicer*** (Figure 1(5))**.** The time slicer enables teachers to freely define a time interval by dragging on the timeline. The defined interval can be moved left or right along the timeline, and its length can be adjusted by resizing its boundaries. Once an interval is created, the three DF1 components update accordingly, and playback starts from the beginning of that interval. **(5)** ***Event indicators*** (Figure 1(6)). Purple event indicators appear above the timeline and display brief summaries of key classroom events, generated by an LLM based on teachers' transcript data. When a user clicks an event indicator, the timeline automatically creates an interval spanning that event's start and end times, and the three DF1 views refresh. **(6)** ***Nodes*** (Figure 1(7)). Each node corresponds to one line of a teacher's discourse. Hovering over a node reveals the associated transcript, and clicking a node updates the DF1 views to that timestamp. The nodes are arranged along four color-coded activity lines, each representing an activity category derived from

teachers' transcript data using an LLM prompted with the Stallings classroom observation framework [17]. The categories are: teacher-led instruction (red), teacher–student interaction (blue), students' independent or collaborative practice (green), and classroom management and transitions (yellow). Because the activity labels and Dandelions are aligned by timestamp, the Dandelions adopt the colors of their corresponding activity types. Additionally, **(7) a filtering panel** (Figure 1(8)) is provided, allowing users to display only those Dandelions associated with a selected color-coded activity type or a specific classroom event.

2.2 System Workflow

The workflow of Multimodal Dandelions consists of two main stages: multimodal data collection and alignment, and automated lesson analysis. The automated lesson analysis stage includes activity classification, key-event extraction, and pedagogical suggestion generation.

First, the system collects and aligns multimodal classroom data. In our study, we collected data from 15 lessons taught by 13 teachers across four classrooms and four grade levels. The collected data include teachers' positioning data, body orientation data, classroom audio, and classroom video. Teachers wore an ID-badge-style Ultra-Wideband (UWB) sensor to capture positioning data, while an inertial measurement unit (IMU) attached to the teacher's waist recorded yaw-based body orientation. Classroom audio was transcribed into timestamped text using automatic speech recognition, and classroom video provided contextual information for each time point. We also measured classroom and desk dimensions and recorded classroom layouts to construct floor maps. The system aligns positioning, orientation, video, and discourse transcript data through timestamps, allowing these multimodal data streams to be synchronously visualized and interacted with on a shared timeline.

Second, the system automatically analyzes the aligned classroom data to identify activity phases, extract key classroom events, and generate pedagogical suggestions based on teachers' discourse. This process is implemented through multiple large language model (LLM) agents, each responsible for a specific analysis task. The audio processing agent cleans the ASR transcripts, filters out students' speech, extracts teachers' discourse, and refines unclear or incomplete utterances based on context. The classroom activity analysis agent classifies the lesson into four activity phases. It also extracts key classroom events and their corresponding time ranges. The discourse analysis agent analyzes teachers' classroom language and generates pedagogical improvement suggestions.

2.3 Implementation

The frontend of Multimodal Dandelions was implemented using Vue. Core visualization and interaction components, including the dynamic Dandelions and interactive timeline were built with D3. Teachers' audio was transcribed using the iFlytek ASR API. The automated lesson analysis pipeline was implemented with multiple large language model (LLM) agents powered by OpenAI GPT-5.2.

3 DEMONSTRATION

When users enter the system, they first see a set of tutorial pages. These pages use GIF animations and textual explanations to introduce the interaction mechanisms of the key design features. After completing the tutorial, users enter the main interface of Multimodal Dandelions.

In the main interface, users can click the play button to start the dynamic replay of the playback-oriented dynamic Dandelions (Figure 1(1)). Color-coded Dandelions are sequentially overlaid on the classroom floor map, with one new mark appearing for each second of classroom data during 1x playback. Together, these marks form a dynamic visualization of the teacher's spatial behaviors over time. Meanwhile, the video viewport (Figure 1(3)) synchronously plays the corresponding classroom video, and the discourse transcription and suggestion panel (Figure 1(2)) automatically scrolls and highlights the transcript line associated with the current timestamp. Users can adjust the playback speed to 1x, 2x, or 5x. They can also use the fast-forward and rewind buttons to browse the data step by step, with each click advancing or reversing the replay by one second.

The interactive timeline presents the classroom process through a sequence of color-coded nodes (Figure 1(7)). Each node corresponds to one line of the teacher discourse transcript, and its color indicates the classroom activity type to which that line belongs. This design allows users to intuitively observe the distribution and proportion of different classroom activities throughout the lesson. When users hover over a node, the system displays the corresponding transcript line. When users click a node, the Dandelions, classroom video, and transcript panel synchronously jump to the corresponding timestamp.

Users can also click and drag on an empty area of the timeline to create a time slicer (Figure 1(5)) of any duration. The time slicer can be freely moved along the timeline, and its boundaries can be adjusted to change the selected duration. Once a time interval is selected, the system updates the Dandelions according to the current interval and synchronously updates the video and transcript content. When users click the play button after selecting an interval, the Dandelions start replaying from the beginning of that interval.

Event indicators are displayed as purple labels above the interactive timeline (Figure 1(6)). Each event indicator corresponds to a pedagogically meaningful classroom event and its duration. When users click an event indicator, the system automatically creates a selected interval on the timeline that matches the duration of the event. The dynamic Dandelions, video viewport, and transcript panel synchronously jump to the start of the selected event. Users can then click the play button to dynamically review that event.

On the right side of the interface, the upper panel displays the video viewport, while the lower panel presents the discourse transcription and suggestion panel. For each transcript line, the panel displays the color code, timestamp, and transcribed teacher discourse. For selected discourse lines, the system also presents pedagogical suggestions generated by the large language model, as shown in Figure 1(4). The filtering panel on the left (Figure 1(8)) allows users to revisit the tutorial and selectively display Dandelions associated with specific classroom activity categories by selecting

or deselecting different color labels. This enables users to filter the visualization according to their reflection needs.

4 USER STUDY

4.1 Procedure

We conducted a user study with eight teachers who had participated in the classroom multimodal data collection. The participants covered four subjects and four grade levels, including seven female teachers and one male teacher, with an average teaching experience of 12.1 years. Throughout the remainder of this paper, these participants are identified as P1 through P8. Appendix B presents further details about the participants' demographic characteristics. Each participant received RMB 100 after completing the study. The study consisted of three stages. The session began with a 10-minute briefing in which the researcher explained the study purpose and demonstrated the system's main functions and interactions. Then, teachers used Multimodal Dandelions to review their own classroom data for about 20 minutes. Finally, they filled out the System Usability Scale (SUS) questionnaire [7] and took part in a semi-structured interview of approximately 20 minutes. The interviews explored participants' reflection processes when using the system, as well as their experiences with its different functions. Interview recordings were transcribed using the iFlytek ASR system and analyzed through thematic analysis [6]. SUS scores were calculated on a 0–100 scale and used to assess the overall usability of the system.

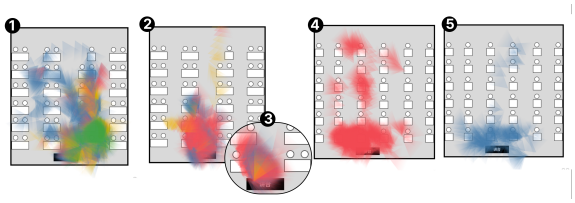

Figure 2: Dandelions from the user study: (1) P1's whole-lesson Dandelions; (2)–(3) P3's whole-lesson and local Dandelions; and (4)–(5) P5's Dandelions during the instruction and teacher–student interaction phases.

4.2 Results

(1) Interactive components supported reflection from global overviews to local moments. By using the nodes, time slicer, and event indicators, teachers could navigate flexibly from whole-lesson patterns to activity phases, salient events, and specific transcript lines. When viewing the default whole-lesson Dandelions, teachers quickly noticed general spatial patterns. For example, P1 mentioned, "I found that I was always oriented toward this direction." As shown in Figure 2(1), P5 stated, "Overall, I moved around different areas of the classroom, but I tended to stay concentrated on one side." Color-coded nodes further supported reflection by activity type. P8 noted that the color-coded timeline helped her quickly see whether the lesson was teacher-centered or student-centered, how much time was spent on classroom management and teacher–student interaction, and when these activities occurred. Event indicators supported more fine-grained review by allowing teachers to selectively inspect meaningful classroom moments. P8 explained, "If this lesson revolves around a key teaching event, I will first look at it."

(2) Flexible scope switching and linked multimodal context helped teachers interpret spatial behaviors. Teachers generated insights by switching between different scopes and connecting spatial visualizations with classroom context. For example, Figure 2(2)–(3), for instance, illustrates how P3 shifted her attention from the overall lesson pattern to a specific classroom moment. After using the time slicer to replay this period, she further reflected that she mostly oriented toward the back door, which might have led her to ignore students in Group Four. Teachers also interpreted Dandelions differently across activity types. As shown in Figure 2(4)–(5), P5 stated, "During instruction, staying mainly at the front is acceptable, but during interaction, I need to move around more." In addition, linked video and discourse data helped teachers contextualize spatial patterns. For example, P4 explained that her frequent orientation toward the blackboard was reasonable because she needed to use the computer to project students' work. P6 also combined AI-generated discourse suggestions with corresponding Dandelions to examine whether his questioning and spatial behaviors jointly supported students' thinking. Overall, teachers did not rely on a single data source; rather, their interpretations and opportunities for improvement emerged from linked spatial, video, and discourse evidence.

(3) The system showed good usability and revealed directions for improvement. Multimodal Dandelions achieved an average SUS score of 79.06 (SD = 8.85, range: 70–95), exceeding the mean SUS score associated with the adjective rating "Good" [5]. Teachers also suggested several future extensions, including adding more positive feedback to maintain motivation (P2), supporting comparison with experienced teachers (P1), extending AI-generated suggestions from discourse to spatial and video data (P6), and enabling long-term analysis of teachers' spatial teaching habits across multiple lessons (P2).

5 CONCLUSION

Multimodal Dandelions combines dynamic spatial visualizations with synchronized video, discourse, and interactive temporal controls to facilitate teachers' reflection across multiple levels of detail. An evaluation with eight teachers indicated that the system helped users contextualize spatial patterns, examine specific classroom moments, and recognize potential improvements to their practice. The findings are constrained by the small sample, short evaluation period, and single-lesson setting. Further research should evaluate the system through larger, longitudinal studies and investigate multimodal AI for more comprehensive pedagogical feedback.

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A Dandelion Diagram

The Dandelion Diagram depicts an individual's spatial position and facing orientation over time. For every recorded moment, the location and heading data are combined into a triangular visual mark resembling a beam of light. The diagram is constructed using three principal design components.

(1) Spotlight Metaphor. In Figure 3(1), the tip of each triangle marks the individual's location, and the triangle extends in the direction that the individual is facing. Encoding these two dimensions within a single mark enables viewers to identify both the person's position and orientation at a glance.

(2) Density Stacking. As illustrated in Figure 3(2), semi-transparent spotlight marks from successive moments are layered on the same spatial map. Areas accumulate greater visual density when the individual repeatedly occupies a similar location or directs their body toward the same region. These variations in density make recurring spatial tendencies visible.

(3) Color Coding. Figure 3(3) demonstrates how color differentiates data belonging to distinct categories. In Multimodal Dandelions, each color corresponds to a classroom activity type, helping teachers examine their spatial behavior in relation to the instructional activity occurring at that time.

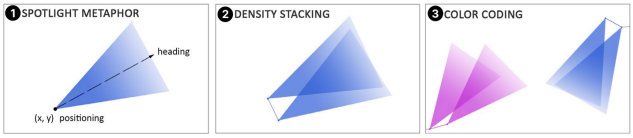

Figure 3: Illustrations of 3 major design components that constitute Dandelion Diagram.

B Teacher Demographics of User Study

ID	Gender(self-identified)	Age	Experience (years)	Grade	Subject
P1	Female	50s	29	4	Science
P2	Female	30s	10	3	Chinese
P3	Female	20s	2.5	4	Math
P4	Female	30s	4.5	3	Math
P5	Female	30s	9.5	5	English
P6	Male	30s	12	5	Math
P7	Female	40s	23	6	Chinese
P8	Female	20s	0.5	6	Chinese