

Multimodal Dandelions: A Playback-Oriented Dashboard for Supporting Multi-Granularity Reflection on Teachers' Spatial pedagogical Behaviors

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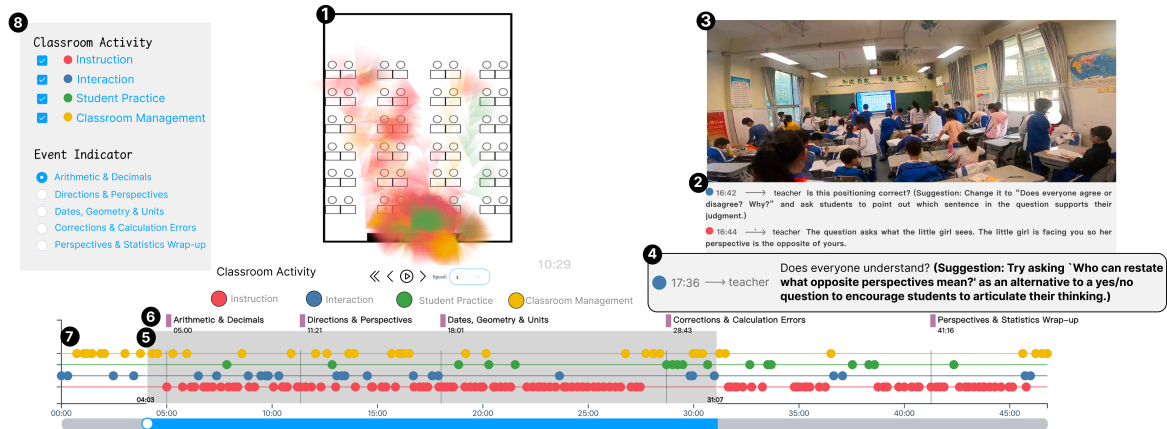


Figure 1: User interface of Multimodal Dandelions. The interface consists of: (1) playback-oriented dynamic Dandelions that visualize teachers' positions and body orientations, (2) a discourse transcription and suggestion panel, (3) a video viewport, (4) LLM-generated suggestions, (5) a time slicer,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

Abstract

Teachers' spatial pedagogical behaviors are important, but their transient nature makes them difficult to reflect on. Traditional methods such as video review are time-consuming and provide limited support for organizing and interpreting spatial behaviors. Reflection dashboards address this challenge by visualizing teachers' spatial teaching data, yet they can be further improved in dynamic representation, multimodal data integration, and multi-granularity interaction. We present Multimodal Dandelions, a multimodal dashboard

that supports teachers' multi-granularity reflection on spatial pedagogical behaviors. The system introduces replayable Dandelions that integrate teachers' position and orientation data. Interactive components, including a time slicer, nodes, and event indicators, allow teachers to switch across whole-lesson overviews, classroom activities, key events, and individual transcript lines. The user study showed that Multimodal Dandelions supported global-to-local reflection, helped teachers interpret their behaviors through multiple data sources, and enabled them to identify opportunities for improvement.

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CCS Concepts

• Human-centered computing → Information visualization.

Keywords

Dashboard, Spatial Pedagogy, Teacher Reflection, Classroom Analytics

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1 INTRODUCTION & BACKGROUND

Teachers' spatial pedagogical behaviors constitute an important part of classroom teaching, shaping classroom organization, teacher-student interaction, attention distribution, and classroom management [11]. However, these behaviors are often fleeting, distributed across classroom space, and difficult for teachers to fully perceive and recall during or after teaching. As a result, teachers may struggle to reflect on their spatial pedagogical practices in a timely and systematic manner [10]. Traditional reflection methods, such as video-based review, are time-consuming. Videos also make it difficult for teachers to quickly revisit and compare spatial behaviors across different moments of a lesson.

Guided by the perspective of spatial pedagogy and enabled by advances in sensing technologies, researchers have increasingly collected data on teachers' spatial pedagogical behaviors and designed visualization and interaction systems to support reflection on spatial teaching. Martinez-Maldonado [12] and ClassBeacons [3] both leveraged teachers' positioning data to represent teachers' proximity to student groups, via heatmap visualizations and wireless lamps distributed across the classroom, respectively. Classroom Dandelions [8] integrates teachers' positioning and orientation data based on F-formation theory, but such data alone may risk over-interpretation without richer contextual information such as discourse and video [2, 8, 14]. Moreover, many existing spatial reflection systems rely on static visualizations, which can obscure how teachers' spatial patterns emerge, accumulate, and shift over time. More dynamic visualizations are thus needed for teacher reflection [9]. Interaction Geography Slicer [15] aligns classroom video and teacher-student discourse with replayable movement trajectories in a space-time cube. However, it does not incorporate orientation data, which is important for inferring teachers' spatial attention and F-formations. Beyond increasing dynamism, more flexible data interactions can further support users in interpreting complex data and generating insights [18]. Prior work has allowed users to select specific time intervals or to filter data by classroom activities or roles [1, 16]. However, few studies have explored how to automatically structure a lesson at different temporal granularities, even though teachers often need to review classroom practices from broader to more local scopes.

We present Multimodal Dandelions, a replayable dashboard that synchronizes teachers' position, orientation, video, and discourse data to support multi-level reflection on spatial pedagogical behaviors. Multimodal Dandelions extends prior systems in three aspects: data modalities, dynamism, and interaction. First, Multimodal Dandelions brings together teachers' position, orientation, classroom video, and discourse data, extending prior spatial reflection systems by providing richer contextual grounding for interpreting

F-formations. Second, beyond showing changes in movement trajectories, Multimodal Dandelions enriches the content presented during playback by showing spotlight changes aggregated from teachers' position and orientation within a given period, as well as accumulated changes in orientation-based proxies of teachers' attentional focus over time. Additionally, our system automatically structures a lesson into multiple temporal perspectives, from different types of classroom activities (e.g., instruction, teacher-student interaction, and student practice) to teaching events and individual transcript lines. It also provides interactive components, such as a time slicer, nodes, and event indicators, to support users in switching across these perspectives.

To evaluate Multimodal Dandelions, we first collected data from 13 teachers across 15 lessons in 5 classrooms at a local primary school. We then conducted a user study with 8 of these teachers. Quantitative and qualitative results show that Multimodal Dandelions supported teachers' reflection at different scopes, from whole-lesson overviews to local classroom moments. Teachers used linked modalities to cross-validate interpretations, contextualize spatial patterns, and identify possible strategies for improving their teaching practices. The results also indicate good usability and reveal teachers' expectations for future functional extensions.

2 METHODOLOGY

2.1 Multimodal Data Collection

We collected teachers' positioning data, body orientation, audio, and video data from 15 lessons taught by 13 teachers across five classrooms. During each classroom session, teachers wore an ID-badge-style Ultra-Wideband (UWB) sensor to capture their positioning data, with four UWB base stations installed at the four corners of the classroom. An inertial measurement unit (IMU) was attached to the teacher's waist to record yaw-based body orientation. Teachers' verbal data were collected using an audio recorder. In addition, a camera was mounted on a tripod at the back of the classroom to capture a panoramic classroom view while avoiding students' facial information. We also measured the dimensions of the classrooms and desks, as well as the classroom layouts, to construct classroom floor maps.

2.2 Design

Multimodal Dandelions is organized around the following two design features (DFs), supported by several interactive components:

DF1: Playback-oriented Dynamic Dandelions Linked with Multimodal Classroom Context. There are three components that support this design feature. (1) *Playback-oriented dynamic Dandelions* (Figure 1(1)). The dynamic Dandelions provide a visual representation that integrates teachers' positioning and orientation data. A detailed introduction of Dandelion Diagram is provided in Appendix A. Playback controls, including play, pause, speed adjustment, fast-forward, and rewind buttons, are provided below the Dandelions. When played at 1x speed, one Dandelion is overlaid on the classroom map every second. This shows how teachers' positions and body orientations change across classroom space over time, and provides an orientation-based proxy for shifts in their attentional focus. (2) *Discourse transcription and suggestion panel* (Figure 1(2)). The panel displays timestamped transcriptions

of teachers' discourse line by line and appends suggestions generated by a large language model (LLM) to certain lines. The LLM prompts are grounded in Bloom's taxonomy [4] and Academically Productive Talk (APT) [13]. For example, as shown in Figure 1(4), following the line "Does everyone understand?", the system appends the 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 presents the classroom recording from the back of the classroom. During playback, the visualizations in these three components are continuously aligned through timestamps.

DF2: Interactive Timeline Supporting Flexible Switching Across Visualization Scopes. Another three interactive components are located on the timeline. (4) **Time slicer** (Figure 1(5)). The time slicer allows teachers to freely create a time interval by dragging on the timeline. The created time interval can be moved left or right along the timeline, and its duration can also be adjusted by resizing its boundaries. Once an interval is created, the three components in DF1 update accordingly, and playback starts from the beginning of that interval. (5) **Event indicators** (Figure 1(6)). Purple event indicators are placed above the timeline and display brief LLM-generated summaries of key classroom events based on teachers' transcript data. When users click an event indicator, the timeline automatically creates an interval corresponding to the start and end times of that event, and the three views in DF1 are updated. (6) **Nodes** (Figure 1(7)). Each node represents one line of teachers' discourse. Users can hover over a node to view the corresponding transcript, and clicking a node updates the DF1 views to the corresponding timestamp. Nodes are arranged along four color-coded classroom activity lines, each representing a classroom activity category generated from teachers' transcript data using an LLM prompted with the Stallings classroom observation framework [17]. The categories include teacher-led instruction (red), teacher-student interaction (blue), students' independent or collaborative practice (green), and classroom management and transitions (yellow). Through timestamp alignment, the corresponding Dandelions are rendered in the same colors. In addition, (7) a **filtering panel** (Figure 1(8)) is provided for users to display Dandelions associated with a selected color-coded activity type or a specific classroom event.

2.3 Implementation

The system front end was implemented using Vue, with core visualization components, including the dynamic Dandelions and interactive timeline, built with D3. Teachers' audio was transcribed into text using the iFlytek ASR API. The LLM workflow adopts a multi-agent architecture, with all agents powered by OpenAI GPT-5.2. The audio processing agent distinguishes teacher and student speech, extracts teachers' discourse, and refines unclear or incomplete transcript lines based on context. The event and activity analysis agent uses teachers' transcript data and timestamps to generate the four activity categories and key-event summaries shown on the timeline. The discourse analysis agent generates pedagogical suggestions appended to certain transcript lines.

2.4 User Study

2.4.1 Participants. We invited eight teachers who had participated in the classroom multimodal data collection to join the user study. The participants covered four subjects and four grade levels, including seven female teachers and one male teacher. Their average teaching experience was 12.1 years. We refer to them as P1–P8. Detailed demographic information is provided in Appendix B.

2.4.2 Procedure. The study consisted of three stages. First, the researcher gave a 10-minute introduction to the study purpose and demonstrated how to use and interact with the system. Second, teachers used the system to review their own classroom data for about 20 minutes. Finally, they completed the System Usability Scale (SUS) questionnaire [7] and participated in a semi-structured interview lasting about 20 minutes. The interview focused on how teachers used the system for reflection and how they experienced its functions.

2.4.3 Data Analysis. The interview recordings were transcribed using the iFlytek ASR system and then analyzed through thematic analysis [6]. We also analyzed the SUS questionnaire responses to assess system usability. Following the standard SUS scoring procedure, responses to positive and negative items were adjusted, summed, and multiplied by 2.5 to produce a final score ranging from 0 to 100.

3 RESULTS

3.1 Teachers' Reflection from Global Overviews to Local Moments

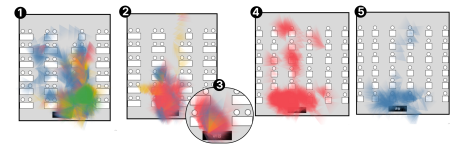


Figure 2: Dandelions from the user study: (1) P1's whole-lesson Dandelions; (2)–(3) P3's whole-lesson and local Dandelions; and (4)–(5) P5's Dandelions during the instruction and teacher-student interaction phases.

3.1.1 Different Components Enabled Reflection at Multiple Scopes and Granularities. Our findings show that Multimodal Dandelions supported reflection across multiple scopes and granularities. Components such as nodes, the time slicer, and event indicators enabled teachers to move between whole-lesson overviews, activity types, key events, and individual transcript lines. For example, when viewing the default whole-lesson Dandelions, 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 teachers in reflecting on their spatial behaviors by activity type. P8 mentioned, "The color-coded nodes on the timeline allow me to quickly see whether this lesson was teacher-centered or student-centered, how much time was spent on discipline management and teacher-student interaction,

and when they were distributed.” Event indicators supported more fine-grained review. P1 and P8 acknowledged their value, stating that they could selectively view certain events according to their own needs. P8 pointed out, “If this lesson revolves around a key teaching event, I will first look at it.”

3.1.2 Flexible Scope Switching Helped Teachers Generate Insights. Teachers also generated insights by flexibly switching between different scopes. For example, Figure 2(2)–(3) shows how P3 moved from an overall to a local view. She first noted that her position was “mostly concentrated around the podium.” 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. In addition, teachers interpreted Dandelions differently across activity types. For example, 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.”

3.2 Multimodal Teaching Contexts Supported Teachers’ Reflection

3.2.1 Linked Multimodal Data Helped Teachers Examine Their Expectations and Assumptions. Teachers used the linked multimodal data to examine their expectations and assumptions. For example, P2 described how she would combine multiple data sources to evaluate whether her lesson reflected student-centeredness: “I would look at whether my Dandelions were close to students, whether I moved to the back of the classroom, what my conversations with students were like at those moments, and then combine this with the proportion of blue (interaction) and green (student practice) to make an overall judgment.” Video data also helped teachers interpret seemingly unusual spatial patterns. For example, after noticing that she frequently oriented toward the blackboard, P4 further used the video to explain the reason: “It turned out that I had to keep using this computer to project students’ work, so it was reasonable that my Dandelions showed orientations toward the blackboard.”

3.2.2 Linked Multimodal Data Helped Teachers Identify Opportunities for Future Teaching Improvement. Linked multimodal data also helped teachers identify ways to improve their future teaching strategies and classroom behaviors. For example, P6 mentioned, “I would first refer to the AI-generated suggestions about my language to see whether my questions guided students’ thinking. Then, I would click on those lines to check whether my Dandelions showed that I oriented toward or moved closer to students at those moments, which helped me understand where I could improve.” By linking each line in the transcript with its corresponding Dandelions, teachers were able to identify specific opportunities for improving their spatial pedagogical behaviors. Similarly, P5 found that her Dandelions were mainly concentrated around the podium and that the proportion of red (instruction) was relatively high. This was further confirmed through the discourse transcription and suggestion panel, leading her to conclude that she needed to leave more time for students’ practice. Overall, our findings show that teachers did not rely on a single data source to interpret their teaching or identify opportunities for improvement. Rather, these

insights emerged through the combination of evidence from linked multimodal teaching contexts.

3.3 Usability of System Functions and Suggestions for Improvement

3.3.1 Overall usability level of the system. The system 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” in Bangor et al.’s interpretation [5]. This suggests that the system demonstrated good usability among the target users, while the interviews further revealed several directions for improvement.

3.3.2 Teachers’ expectations for future improvements. (1) Increasing positive feedback. As P2 mentioned, if the system focuses too much on problems and shortcomings, it may reduce teachers’ motivation for continued use. Therefore, P2 suggested adding more positive feedback to enhance teachers’ sense of achievement and willingness to use the system: “If the system only tells me where I did not do well, it will instead undermine my motivation to use it.” **(2) Supporting comparative analysis with experienced teachers.** P1 suggested that the system could support comparison with experienced teachers. By importing lessons from experienced teachers, teachers could identify gaps in their own classroom practices: “I hope some lessons by experienced teachers can be imported, so that we can see where the gap is between us and them.” **(3) Strengthening AI suggestion generation based on multimodal data.** Currently, the AI-generated suggestions only target teachers’ language. P6 stated, “If there were also an AI analysis function for my Dandelions, reminding me where to go and how to move, that would be even better.” **(4) Combining long-term data for continuous analysis.** Teachers mentioned that they hoped the system could support long-term data analysis and explain their teaching patterns and habits. P2 stated, “I hope long-term data analysis can help me identify my spatial teaching patterns. Although I have been teaching for almost 30 years, I still do not know much about them.”

4 CONCLUSION, LIMITATIONS AND FUTURE WORK

In this work, we presented Multimodal Dandelions, a replayable dashboard that integrates teachers’ position, orientation, video, and discourse data to support spatial reflection. A user study with eight teachers showed that dynamic Dandelions and interactive elements, including the time slicer, nodes, and event indicators, supported reflection across different temporal scopes and levels of granularity. By combining multimodal context, teachers could verify and interpret their spatial behaviors and identify opportunities for improvement. This work is limited by its small sample size, short study period, and single-lesson reflection setting. Future work can involve more participants, conduct long-term deployment studies, and explore multimodal AI analysis to generate richer pedagogical suggestions.

Acknowledgments

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References

- [1] Riordan Alfredo, Paola Mejia-Domenzain, Vanessa Echeverria, Dwi Rahayu, Linxuan Zhao, Haya Alajlan, Zachari Swiecki, Tanja Käser, Dragan Gašević, and Roberto Martinez-Maldonado. 2025. TeamTeachingViz: Benefits, Challenges, and Ethical Considerations of Using a Multimodal Analytics Dashboard to Support Team Teaching Reflection. In *Proceedings of the 15th International Learning Analytics and Knowledge Conference*. 58–69.
- [2] Sakinah Alhadad. 2016. Attentional and cognitive processing of analytics visualisations: Can design features affect interpretations and decisions about learning and teaching?. In *ASCLITE 2016*. Australasian Society for Computers in Learning in Tertiary Education (ASCLITE).
- [3] Pengcheng An, Saskia Bakker, Sara Ordanovski, Ruurd Taconis, Chris LE Paffen, and Berry Eggen. 2019. Unobtrusively enhancing reflection-in-action of teachers through spatially distributed ambient information. In *Proceedings of the 2019 CHI conference on human factors in computing systems*. 1–14.
- [4] Lorin W Anderson and David R Krathwohl. 2001. *A taxonomy for learning, teaching, and assessing: A revision of Bloom's taxonomy of educational objectives: complete edition*. Addison Wesley Longman, Inc.
- [5] Aaron Bangor, Philip Kortum, and James Miller. 2009. Determining what individual SUS scores mean: Adding an adjective rating scale. *Journal of usability studies* 4, 3 (2009), 114–123.
- [6] Virginia Braun and Victoria Clarke. 2013. *Successful qualitative research: A practical guide for beginners*. (2013).
- [7] John Brooke et al. 1996. SUS-A quick and dirty usability scale. *Usability evaluation in industry* 189, 194 (1996), 4–7.
- [8] Gloria Fernandez-Nieto, Pengcheng An, Jian Zhao, Simon Buckingham Shum, and Roberto Martinez-Maldonado. 2022. Classroom dandelions: Visualising participant position, trajectory and body orientation augments teachers' sensemaking. In *Proceedings of the 2022 CHI Conference on Human Factors in Computing Systems*. 1–17.
- [9] Ilana Horn and Brette Garner. 2022. *Teacher learning of ambitious and equitable mathematics instruction: A sociocultural approach*. Routledge.
- [10] Jeffery A Lackney. 2008. Teacher environmental competence in elementary school environments. *Children, Youth and Environments* 18, 2 (2008), 133–159.
- [11] Fei Victor Lim, Kay L O'Halloran, and Alexey Podlasov. 2012. Spatial pedagogy: Mapping meanings in the use of classroom space. *Cambridge journal of education* 42, 2 (2012), 235–251.
- [12] Roberto Martinez-Maldonado. 2019. "I Spent More Time with that Team" Making Spatial Pedagogy Visible Using Positioning Sensors. In *Proceedings of the 9th international conference on learning analytics & knowledge*. 21–25.
- [13] Sarah Michaels and Cathy O'Connor. 2012. Talk science primer.
- [14] Neil Selwyn and Dragan Gašević. 2020. The datafication of higher education: Discussing the promises and problems. *Teaching in Higher Education* 25, 4 (2020), 527–540.
- [15] Ben Rydal Shapiro, Elizabeth C Metts, and Edwin Zhao. 2025. The Interaction Geography Slicer: Designing Exploratory Spatial Data Visualization Tools for Teachers' Reflective Practice. In *Proceedings of the 2025 CHI Conference on Human Factors in Computing Systems*. 1–17.
- [16] Ben Rydal Shapiro, Deborah Silvis, and Rogers Hall. 2025. Visualization as theory and experience: interactive qualitative data visualization for the learning sciences. *Journal of the Learning Sciences* 34, 5 (2025), 840–871.
- [17] Jane A Stallings and David H Kaskowitz. 1974. Follow Through Classroom Observation Evaluation 1972-1973. SRI Project URU-7370. (1974).
- [18] Ji Soo Yi, Youn ah Kang, John Stasko, and Julie A Jacko. 2007. Toward a deeper understanding of the role of interaction in information visualization. *IEEE transactions on visualization and computer graphics* 13, 6 (2007), 1224–1231.

A Dandelion Diagram

The Dandelion Diagram visualizes a person's position and body orientation at different moments in time. Each data point contains a spatial location and a heading direction, which are represented together as a spotlight-like triangular mark. Below are the three main design components of the Dandelion Diagram.

(1) Spotlight Metaphor. As shown in Figure 3(1), the vertex of the triangle indicates the person's position, while the direction of the triangular shape represents the person's heading direction. This allows the visualization to simultaneously represent where a person is located and where they are facing.

(2) Density Stacking. Figure 3(2) illustrates density stacking. Multiple semi-transparent spotlight marks are overlaid across time. When a person remains in or repeatedly faces toward similar areas,

the overlapping marks become visually denser, revealing accumulated spatial patterns.

(3) Color Coding. Figure 3(3) shows color coding. Different colors can be used to distinguish different categories of data. In our system, color coding represents different classroom activity types, allowing teachers to interpret spatial behaviors together with instructional contexts.

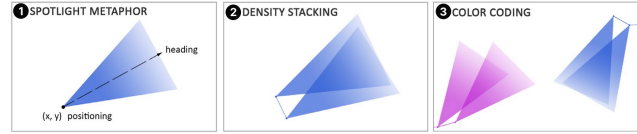


Figure 3: Illustrations of 3 major design components that constitute Dandelion Diagram.

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