System 133 (2025) 103732

Contents lists available at ScienceDirect

System

journal homepage: www.elsevier.com/locate/system

Adapting to Complexity: Teacher-Student interactions in synchronous online language classes through a dynamic systems lens

Huan Huang [a], Michael Li [b,*], Chujie Dai [c]

[a] Shantou University, School of Humanities, 243 University Road, Shan Tou City, Guangdong Province, 515063, China
[b] Massey University, School of Humanities, Media and Creative Communication, Massey University East Precinct Albany Expressway, SH17, Auckland, 0632, New Zealand
[c] Guangdong Ocean University, School of Literature, Journalism & Communication, 1 Haida Road, Zhang Jiang City, Guangdong Province, 524091, China

ARTICLE INFO

Keywords:
Complex dynamic systems theory (CDST)
Teaching Chinese as a second language (TCSL)
Classroom interaction
Co-adaption
Second language pedagogy

ABSTRACT

Teacher-student interaction is widely recognized as critical to the success of language learning. However, there remains a significant gap in understanding these interactions from a non-linear systems perspective, particularly in online learning environments. This study applies Complex Dynamic Systems Theory (CDST) to investigate the co-adaptive patterns of teacher-student exchanges in online Chinese language classes. By examining real-time interactions and their dynamic nature, we analyzed how interactional patterns evolved and shaped the learning process, using a visualized coding scheme to focus on variations within and between teachers. The study involved 23 adult students studying Chinese as a second language in a Chinese university, with data collected from 12 lessons across a semester. Our analysis identified predominant patterns, such as a frequent reliance on closed questions followed by short responses. While students adjusted their answers based on question complexity, teachers often did not, revealing a lack of adaptability in their questioning techniques. The study calls for further exploration and improved training in adaptive questioning strategies, as this remains a challenge across both online and offline settings. These findings highlight the need for flexible and responsive teaching to meet the increasing demands of dynamic online learning environments.

1. Introduction

Classroom interaction has been widely acknowledged as an essential element of classroom dynamics, especially in L2 teaching where it plays a crucial role in learners' L2 development (Heins et al., 2007). Recent studies have recognized the complexity and dynamic nature of classroom interaction in language education. For instance, Seedhouse (2010) explored the characteristics of spoken interaction as a complex adaptive system, with a particular focus on the Initiation-Response-Feedback pattern. Larsen-Freeman (2022) emphasized the importance of understanding this interaction as a complex, non-linear process, highlighting the role of learners in this process. From the perspective of Complex and Dynamic System Theory (CDST), Smit et al. (2022) extended this discussion by investigating the interaction between the cognitive levels of teacher questions and student answers and analyzing the complex

* Corresponding author.
E-mail addresses: huanhuang7@stu.edu.cn (H. Huang), s.li.1@massey.ac.nz (M. Li), chujie.dai@hotmail.com (C. Dai).

https://doi.org/10.1016/j.system.2025.103732
Received 20 October 2024; Received in revised form 25 May 2025; Accepted 31 May 2025
Available online 2 June 2025

dynamic process of co-adaptation between teachers and students in an EFL context. In parallel, researchers such as Gibbons, 2002 and McNeil (2012) have drawn attention to scaffolding as a key instructional practice that supports learners through contingent questioning and dialogic support. Adaptive teaching strategies—including differentiated questioning (Xia, 2020) and interpersonal engagement techniques (Yang, 2021)—have been shown to facilitate more responsive and learner-centered interactions. These studies highlight the need for deeper insights into classroom dynamics, as well as the development of scaffolding and adaptive teaching practices, to enhance learning opportunities in classroom settings.

This complexity in teacher-student interaction is particularly evident in the field of Teaching Chinese as a Second Language education (TCSL). There has been a growing interest in learning Chinese for economic benefits, cultural understanding, and aiding comprehension within an increasingly multicultural society (Shi & Stickler, 2018). However, the unique linguistic characteristics of Chinese language pose significant challenges for speakers of other languages in developing speaking skills during classroom interactions (Song, 2009). As highlighted by Shi and Stickler (2018), the tonal and character components of the Chinese language introduce additional challenges for learners when it comes to processing text input and translating it into spoken language. Research also indicates that when faced with low engagement or no responses from students, the interaction between teachers and students might encounter serious obstacles, potentially leading to awkward silences, which in turn reduces teaching efficiency and quality (e.g., Liu, 2016).

Empirical studies highlight key differences in interaction dynamics between TCSL and ESL classrooms. Qi and Du (2008) note that TCSL classroom interaction in mainland China is rarely studied empirically, limiting practical guidance for teachers. Their findings show significantly fewer questions in intermediate-level TCSL classes compared to ESL classrooms. For instance, while White and Lightbown (1984) reported around 200 questions in a 45-min ESL class, Qi and Du found only 126 in a 90-min TCSL class, with some teachers asking fewer than 100. Though question frequency alone does not determine interaction quality, classes with fewer questions received the lowest student evaluations. Qi and Li (2009) further observed that CSL classroom interaction in China differs from North America, where effective questioning strategies yield higher student talk ratios. Liu (2016) found that CSL classrooms prioritize knowledge transmission over cognitive development and dialogue, unlike Western classrooms. Studies such as Richards and Lockhart (2007) and Şeker and Kömür (2008) emphasize higher-order questioning in ESL classrooms to foster critical thinking, suggesting potential benefits for CSL classrooms.

As the TCSL field evolves, online classrooms have become an increasingly important modality of instruction. In particular, synchronous online teaching has introduced new dynamics in teacher-student interaction. The COVID-19 pandemic and the development of synchronous communication technology platforms, such as ZOOM, have led many teachers to conduct teaching activities online. Although these platforms create an environment similar to face-to-face communication, significant differences in teacher-student interaction between online and offline teaching have been noted. For instance, online teaching often lacks student-student interaction (Shi & Stickler, 2018), and teachers' discourse accounts for a higher proportion of the class compared to offline settings (Heins et al., 2007). Additionally, Hu (2021) found that while the quantity of teacher questions remains similar in online and offline settings, online teachers tend to ask more closed questions and fewer open questions. These shifts give rise to new forms of complexity in interaction, where multiple interrelated factors—such as question type, learner responsiveness, and technological constraints—interact in unpredictable ways. The dynamics of online CSL classrooms also unfold moment by moment, as teachers and students continuously adjust to each other's input, engagement levels, and the affordances or limitations of the platform. Understanding these characteristics is critical for examining how online teaching environments shape communication patterns and pedagogical responsiveness.

Despite existing research on general language teaching and offline CSL settings, little is known about the complex, dynamic nature of teacher-student interactions in synchronous online CSL classrooms. Current studies often overlook how moment-to-moment interactions, as made visible through coding schemes such as QAELT (Smit et al., 2022), reveal opportunities for adaptive questioning strategies. Additionally, there is limited understanding of how the cognitive levels of teacher questions and student answers co-adapt and how pedagogical approaches influence interaction patterns, impacting student engagement and learning in the online environment. This study adopts a perspective informed by CDST to identify dominant patterns in teacher questioning, examine variations in dynamic interactions across sessions, and explore how teachers and students co-adapt based on cognitive levels of questions and responses.

Addressing these gaps is crucial for several reasons. First, understanding the dominant teacher-student interaction patterns in online CSL classrooms offers insights into the adaptive processes of language learning from a dynamic systems perspective. Second, identifying the co-adaptive nature of these interactions can inform educators about how teacher questioning and student responses evolve dynamically over time. Lastly, by analyzing the predominant question-answer patterns, this study highlights the need for adaptive questioning strategies that might better engage students and create opportunities for deeper cognitive engagement in online learning environments.

2. Literature review

2.1. Current research on teacher-student interaction in L2 classrooms

Teacher-student interactions are critical for language acquisition, with questioning techniques being central to facilitating effective communication and learning (Yang, 2021). In this study, we adopt the terms "open" and "closed" questions to align with the QAELT coding framework. These correspond to what prior literature has referred to as 'referential' and 'display' questions, respectively (Long & Sato, 1983; Zhang et al., 2009). Traditionally, research has focused on categorizing questions as open versus closed, noting that open

questions foster deeper interactions by eliciting more elaborate responses, while closed questions tend to limit discourse to shorter answers (Gibbons, 2002). However, empirical findings reveal that ineffective questioning persists in many classrooms, underlining the need for further exploration of how questioning strategies impact interactions across various L2 contexts (McNeil, 2012).

Recent studies have examined innovative strategies to enhance engagement in L2 classrooms. For instance, Yang (2021) demonstrated that interpersonal elements in questioning, such as using personal pronouns and modal verbs, can increase interaction by directly engaging students. Xia (2020) showed that training teachers in cognitive domain questioning strategies increased the use of higher-order questions, leading to more reflective and engaged student responses. Likewise, Chen (2021) observed that well-crafted questioning strategies promoted nuanced and complex responses, advancing classroom dynamics.

In the context of online teaching, the unique challenges posed by virtual environments have also prompted adjustments in questioning strategies. Moorhouse et al. (2023) observed that teachers in online settings often began with closed questions to engage the whole class, before transitioning to open questions aimed at eliciting longer oral responses from a few students. These strategies aim to maintain engagement in the more constrained dynamics of virtual classrooms.

In TCSL, research on teacher questioning strategies similarly emphasizes the importance of question types. Long and Sato (1983) first identified open and closed questions, noting that open questions tend to prompt more genuine, information-rich responses. This was supported by Zhang et al. (2009), who found that open questions led to more authentic and lengthier responses from students in a Singapore elementary school, while closed questions were more likely to elicit shorter answers. While expanding these question categories, Jin (2017) pointed out that merely classifying questions does not fully capture the complexity of interactions or explain their impact on learning outcomes. It is essential to examine how questions interact dynamically with student responses to understand the evolving nature of classroom discourse and how these interactions influence learning processes.

Studies on online language teaching reveal distinct interaction patterns compared to face-to-face settings. For example, Heins et al. (2007) found that online tutorials tend to involve more structured output and tutor dominance, limiting spontaneity. Similarly, Hu (2021) noted that teachers in online classrooms asked more closed questions and fewer open questions, highlighting the need for adaptive questioning strategies to address technical delays and longer wait times. Established frameworks, such as the Initiation-Response-Feedback (IRF) model, have greatly enhanced our understanding of classroom discourse by providing a structured approach to analyzing interactions. Shi and Stickler (2018) observed that online Chinese tutorials often followed an Initiation-Response-Feedback pattern, demonstrating the need for careful interaction management to enhance student engagement and spontaneity in virtual settings.

2.2. The CDST framework

As learning environments become more complex, particularly in online settings, there is a growing need for approaches that can capture the fluid and evolving nature of these interactions. CDST views language development and classroom interactions as dynamic, nonlinear processes, better suited for understanding the variability and adaptability inherent in online contexts (de Bot et al., 2007; Larsen-Freeman & Cameron, 2008).

CDST offers a lens for understanding classroom interactions as dynamic, adaptive processes shaped by mutual co-adaptation between teachers and students (Larsen-Freeman, 2022). In this perspective, interactions between teachers and students are interconnected, and their development over time represents a collective variable, emerging not from the language of either participant alone, but from their ongoing interplay (Smit et al., 2022). For instance, Larsen-Freeman and Cameron (2008), regarded language classroom as a complex dynamic system. They used the "interaction differential", a collective variable representing the gap between teacher-expected and learner-actual responses, to measure interaction development over time.

Building on this view, classroom interactions can be understood as a self-organizing process where patterns emerge through ongoing adjustments and feedback loops between participants (Larsen-Freeman & Cameron, 2008). This dynamic process leads to the emergence of discernible patterns, which over time, may stabilize into self-reproductive and self-maintaining states known as "attractor states" (van Dijk et al., 2024). Theoretically, in early stages of a class—such as when a teacher first engages a new group of students—no fixed routines exist, and the system remains highly flexible. Over time, however, recurring behavioural patterns may stabilize into attractor states. For example, Smit et al. (2022) developed a coding scheme, known as the Questions and Answers in English Language Teaching (QAELT, details on methodology part) coding scheme, to categorize and describe the questions posed by four English teachers and the responses of learners in 16 lessons. Smit's study revealed that in the language classrooms of three out of the four teachers, the dominant interaction pattern consisted of teacher-led closed questions followed by brief student answers.

One of the key characteristics of an attractor state, once established, is its high resistance to change. Considerable effort is required to disrupt these entrenched patterns, even though the system retains some degree of variability (de Bot et al., 2007; Hollenstein, 2013). However, these states are not static; rather, they fluctuate based on discourse intentions and classroom context (Smit et al., 2022). In L2 classrooms, this flexibility and variability allows for a more nuanced understanding of how teacher-student interactions adapt to varying cognitive demands and classroom conditions. For instance, using CDST, Smit et al. (2022) utilized State Space Grids to visualize classroom interaction patterns and quantify intra-individual variability within each lesson. The results indicate that teachers and students need to enhance their level of mutual adaptation to improve the quality of classroom interactions. This finding is crucial in highlighting the asymmetric adaptation that occurs in physical classroom interactions, something traditional models might not capture fully.

CDST's emphasis on variability and adaptation is particularly relevant for online education, where the absence of physical cues and the constraints of digital platforms often shape more controlled patterns of interaction. Despite increasing reliance on synchronous online instruction, the moment-to-moment dynamics of teacher-student exchanges in such contexts remain underexplored. Guided by

a CDST perspective, this study investigates dominant patterns of interaction in online CSL classrooms using the QAELT coding scheme (Smit et al., 2022). While CDST provides a broad lens for understanding the complex and emergent nature of language classroom dynamics, QAELT offers a focused operationalization of one subsystem—namely, question and answer exchanges—enabling a close analysis of variation and co-adaptation over time within this bounded domain. Specifically, this study focuses on the cognitive levels of teacher questions and corresponding student responses in real-time classroom discourse. By examining how questioning strategies are used and how students respond in context, it aims to illuminate the ways in which teacher-student interactions dynamically co-adapt based on question complexity. Unlike traditional models that categorize questions as open or closed, this CDST-informed approach supports a more nuanced understanding of whether teacher questioning and student answering can remain anchored in one dominant interactional pattern (e.g., closed questions and short answers) while still exhibiting variation both within individual lessons and across different teachers.

This study serves as a conceptual replication, building on Smit et al. (2022) by extending their research to a new linguistic and instructional context. While Smit et al. examined teacher-student interactions in physical ESL classrooms, this study explores similar dynamics in the virtual environment of synchronous CSL settings. These differences underscore the value of conceptual replication in testing theoretical frameworks across languages, environments, and modalities. By applying the QAELT coding scheme to online teaching and addressing the complexities of Chinese as a tonal, character-based language, this study refines QAELT and reinforces the broader relevance of Smit et al.'s insights. This highlights the importance of conceptual replication in uncovering context-sensitive dynamics while advancing theoretical and practical understanding in second language pedagogy (Derksen & Morawski, 2022).

3. Research questions

RQ1: What are the dominant patterns of teacher questions and student answers in these online classes?
RQ2: How do these interaction patterns vary across different lessons and teachers?
RQ3: What is the relationship between the cognitive levels of teacher questions and student answers through the lens of co-adaptation?

4. Methodology

4.1. Research context and participants

The study was conducted at a university in eastern China during the second semester of 2021, which ran from September to December. The 16-week course used the intermediate-level "*Experiencing Chinese Oral Course*" textbook, which focuses on enhancing spoken Chinese skills through interactive and communicative activities. Classes were held three times per week, each lasting 1.5 h. Two intermediate Chinese language classes agreed to participate in the study, comprising a total of 23 adult students from diverse cultural backgrounds, including Thailand, Vietnam, South Korea, Kenya, and Sri Lanka. The sample size of 23 students provided diversity while remaining manageable for quantitative analysis, ensuring the generalizability of findings to similar settings. Previous research in similar contexts (Heins et al., 2007; Smit et al., 2022) has shown that this sample size is appropriate for capturing a broad range of interaction dynamics without overburdening the analysis.

The students were divided into two parallel online classes, each taught by two different teachers. All participants were at an intermediate level, having passed either level three or four in standardized Chinese proficiency tests (HSK 3 or 4). However, due to the impact of COVID-19, which affected student registration and availability, the class sizes were uneven: one class consisted of seven students, while the other had sixteen. This disparity in class sizes reflects real-world constraints, such as varying student schedules and practical challenges in organizing online classrooms during the pandemic. Despite this imbalance, the two classes provided complementary insights: the smaller class allowed for detailed observation of individual student participation and personalized interactions, while the larger class offered valuable data on the dynamics of a more typical, crowded online learning environment.

The two teachers in this study have distinct backgrounds and teaching experiences. Teacher A, who holds a PhD in Chinese classical

Table 1
A summary of teaching activities.

	Teacher A's classes (with seven students)	Teacher B's classes (with sixteen students)
Session 1 (October)	practice drills based on a text practicing new vocabulary doing sentence-making exercises	discussing cultural customs reading text fill-in-the-blank exercises practicing new vocabulary
Session 2 (October)	doing post-text exercises related to the internet	sharing cultures of different countries learning internet-related terms
Session 3 (November)	discussing online life completing fill-in-the-blank exercises	doing word chain activity discussing online life and life without the internet
Session 4 (November)	Learning new text learning new vocabulary	sharing and discussing student essays titled "Ideal Home"
Session 5 (December)	doing exercises from previous lesson learning text of a new lesson describing people	discussing a short passage about marriage
Session 6 (December)	post-class exercises learning new vocabulary practicing sentence-making exercises	reading the text and discussing things students want their parents to do listening exercise about retirement

literature, primarily teaches literature and cultural courses but has over ten years of experience teaching oral Chinese. Teacher B, with a master's in literature, has over 30 years of TCFL experience. She has taught extensively both in China and abroad, training local Chinese language teachers in multiple countries and authoring textbooks on spoken Chinese and language learning strategies.

4.2. Data collection, transcription and validation

After obtaining consent from the participants in September, the study observed a total of 12 lessons, each lasting approximately 1.5 h. The lessons were deliberately selected from the beginning (October), middle (November), and end of the semester (December) to capture interaction patterns at different stages of the learning process. This selection ensured a broad temporal scope, capturing possible changes in teacher-student dynamics over time. The lessons were chosen to represent a variety of teaching phases, providing a balanced view of interaction dynamics across different stages of curriculum progression. While this approach allowed for a comprehensive observation of the class dynamics, it may introduce a potential limitation, as interactions during other lessons outside of these phases were not examined. This focus on selected lessons, though, aligns with the study's qualitative goals of capturing key interaction patterns over time rather than delivering an exhaustive review of every classroom session. Table 1 provides a summary of the activities implemented in the 12 sessions.

The lessons were conducted online via *Tencent Meeting*, a platform similar to ZOOM, reflecting the digital learning environments that have become increasingly prevalent. Teachers recorded the lessons for research purposes, and written consent was obtained from both teachers and students prior to data collection. The study received approval from the ethics committees of the authors' universities (Approval No. 4000029121) to ensure adherence to ethical research standards.

All recorded lessons were transcribed verbatim in Chinese using a software *InqScribe* (Inquirium, 2020), with both the authors and the teachers independently verifying the accuracy of the transcriptions. This process was crucial for ensuring that the transcripts reflected the nuances of the teacher-student interactions and captured the exact wording of questions and responses. Double-checking the transcripts also mitigated potential transcription errors and ensured that the analysis was based on precise and reliable data.

4.3. Data coding

This study adapted the original Question-Answer-English-Language Teaching (QAELT) coding scheme developed by Smit et al. (2022) to analyze teacher-student interactions in Chinese as a Foreign Language classrooms. To reflect the contextual and methodological adjustments made for this study, we refer to this adapted version as QACLT (Questions and Answers in Chinese Language Teaching). QACLT categorizes teacher questions and student responses based on cognitive complexity, using State Space Grids (SSGs) to track interaction patterns. It classifies teacher questions into non-elicitation, closed, clarification, and open-ended types, while student responses range from no answer to complex, multi-sentence replies. By capturing moment-to-moment variability, QACLT helps reveal whether teachers adjust their questioning strategies based on student responses and whether classroom interactions exhibit rigid or adaptive characteristics.

QACLT is relevant to this study as it provides a structured method for analyzing teacher-student interactions in online CFL classrooms. However, applying it to CFL presents challenges. Chinese, as a tonal and character-based language, requires different cognitive processing, which may influence response patterns in ways QAELT does not fully capture. Additionally, online settings introduce delays, reduced spontaneity, and greater reliance on non-verbal cues, which the framework does not explicitly address. Furthermore, short responses in CFL may result from retrieval difficulties rather than disengagement, requiring a nuanced interpretation.

Because this study was conducted in an online teaching environment, the QACLT framework required modification to account for the distinct interactional dynamics present in virtual classrooms. First, the immediacy and spontaneity of face-to-face communication are reduced due to factors such as delays, technical glitches, and limited access to non-verbal cues (e.g., facial expressions, gestures). Consequently, it is more difficult to gauge real-time student engagement and reactions, which can affect the flow of questioning and response patterns.

To address these complexities, the coding scheme was adapted to handle non-teaching-related teacher talk, which is more common in online settings. For example, questions related to technological issues—such as ensuring students can see the screen or hear the teacher properly—were prevalent in online classes but did not contribute directly to the learning discourse (see Excerpt 1). These types of questions, though important for maintaining classroom function, were excluded from the core analysis to avoid skewing the data on teaching-related interactions.

Excerpt 1 (Teacher B session 1).

教师:比如说我现在写了绿色的字。能看见吗?

Teacher: for example, I am writing a word in green, can you see it?

Given the frequency of such technology-related interactions, specific adaptations were made to the QACLT framework:

a. Non-teaching-related questions (such as those related to technology or student attentiveness) were initially coded as "T" during the first round of annotation but were excluded from further analysis. These questions were not considered part of teaching-related teacher questions, as their primary function was to ensure technical functioning rather than to advance learning.
b. Filler or procedural questions, such as confirming task completion or reading aloud from the textbook, were also excluded as they did not elicit meaningful responses relevant to the cognitive level of interaction.

The transcribed corpus was exported to Excel and coded in two stages. In the first stage, each teacher-student interaction was identified and annotated sequentially. Each interaction, defined as an event, began with the teacher's question and ended with the student's response or the start of a new teaching-related activity (e.g., video playback, group work). Rotational questioning (e.g., calling on students by name to respond to the teacher's question, either after no response from a previous student or to elicit varied perspectives from multiple students) was treated as a new event.

In the second stage, these interactions were classified into four levels based on the cognitive complexity of both the teacher questions and the student answers. These levels, outlined in Table 2 and developed by Smit et al. (2022), ranged from non-elicitation (i.e., questions that do not expect a response) to open questions that prompt no response to complex answers. All coding decisions were based on the original Chinese transcripts. While some translated responses may appear more elaborate in English, categorization followed the length and completeness of the Chinese utterances. Specifically, teacher questions are categorized as follows: 0 for non-elicitation, 1 for closed questions, 2 for clarification questions, and 3 for open-ended questions. Similarly, student answers are categorized into four levels: 0 for no response, 1 for simple answers, 2 for complete answers, and 3 for complex answers. For instance, if a teacher asks an engagement question (i.e., a clarification question), which is coded as 2, and the student does not provide a response, which is coded as 0 (no response), the entire interaction is coded as a combination: (2, 0). The online context often introduced additional variability in response length and quality due to factors such as internet connectivity, which influenced student engagement and participation. To account for this, our coding framework focused on the communicative function of responses rather than superficial differences in length or fluency, ensuring consistency in classification.

While we acknowledge that student responses do not always fit neatly into exclusive categories—such as a complete answer being relatively brief—we mitigated this issue by adhering to a strict coding framework adapted from Smit's (2022) QAELT scheme and applied here as QACLT. Overlaps are an inherent feature of natural classroom discourse, but we minimized ambiguity by refining our coding definitions and applying consistent coding criteria based on utterance length, response completeness, and communicative function. This systematic approach ensures reliability and replicability in our analysis, maintaining the trustworthiness of our findings.

The online medium also necessitated adjustments in the handling of response delays or incomplete answers. For example, technical delays were common, causing pauses between teacher questions and student answers. These instances were coded as part of the interaction but marked to differentiate them from typical pauses in face-to-face settings. This adaptation ensured that long pauses due to technical issues did not inflate the perceived response time or misrepresent the interaction dynamics.

To ensure the reliability of the coding process, two researchers independently coded 20 % of the transcriptions using the QACLT coding scheme. After training sessions and detailed discussions, inter-rater reliability was measured at a Cohen's kappa of .86, indicating high agreement. Discrepancies were resolved through consensus, and regular meetings were held to refine the coding guidelines as needed. Following this, the refined coding guidelines were applied to the full dataset in two phases. In the first round, each author independently applied the refined coding guidelines to the transcriptions. In the second round, the authors reviewed each other's coding results, discussed any remaining discrepancies, and further refined the coding framework to ensure consistency and accuracy. Since this second stage involved consensus coding rather than independent coding, no additional Cohen's kappa was calculated. Instead, the focus was on ensuring interpretive consistency and conceptual clarity across the dataset. This iterative process strengthened the validity and reliability of the coding outcomes, providing a robust foundation for subsequent data analysis.

4.4. Data analysis

This study used GridWare software (Hollenstein, 2013) to analyze teacher-student interaction data. GridWare visualizes interaction

Table 2
Codes and descriptions of teacher question and student answers (adapted from Smit et al., 2022) and implemented as QACLT in this study.

TQ Code	Teacher question category and example	SRCode	Student response category and example
0	**Non-elicitation question** The teacher does not expect student to answer. Example: 英文叫register,汉语叫什么?叫注册。 *In English it is called register, what is it called in Chinese? It is called zhu ce.*	0	**No respond** Students do not respond.
1	**Closed Question** The teacher expects a specific answer. Example: 你觉得容易还是难?*Do you find it easy or difficult?*	1	**Simple Answer** Students give simple answers (1–3 words), not in complete sentences. Example: 难. *Difficult.*
2	**Clarification Question** The teacher encourages the student to express their opinions briefly or checks their understanding. Example: 你觉得哪种聊天方式好?面对面,还是在网上?*Which way of chatting do you think is better? Face-to-face or online?*	2	**Complete Answer** Students give complete answers but do not provide additional information. Example: 我觉得面对面更好。*I think face-to-face is better.*
3	**Open-ended Question** The teacher invites the student to share their thoughts more freely and with some detail. Example: 你觉得网上聊天跟现实生活中聊天有什么不一样?*What do you think is the difference between chatting online and chatting in real life?*	3	**Complex Answer** Students provide complete answers and additional information (more than one sentence). Example: 见面聊天让我们更亲密,但是我也喜欢在网上交朋友。一样的共同点,可以聊天得很高兴。*Chatting face-to-face brings us closer, but I also enjoy making friends online. Having shared interests allows for enjoyable conversations.*

events on a 4 × 4 state-space grid, with each cell representing a unique teacher-question and student-response combination. This visualization allows for the analysis of both static frequencies and dynamic changes in interaction patterns.

The software also calculates several key indicators of system dynamics and flexibility, including the cell range (the number of unique cells visited in the grid) and the dispersion coefficient, which measures the variability of the system's states over time. The dispersion coefficient ranges from 0 to 1, where 0 indicates that all interactions are concentrated in one cell (a highly stable pattern), and 1 indicates that interactions are evenly distributed across all cells (a highly variable pattern) (Hollenstein, 2013).

To identify dominant interaction patterns, the attractor value was calculated for each class session. First, the cell with the highest frequency of teacher-student interactions was identified as the attractor state. Then, the number of interactions in this cell was divided by the total number of interactions in that lesson and multiplied by 100. The resulting percentage reflects the degree to which interactions were concentrated within a specific question-answer pattern, with higher values indicating stronger attractor effects.

In addition to these dynamic indicators, we also examined the relationship between the levels of teacher questions and student responses using correlation analysis. A delayed pairing method was used to explore whether teacher questioning adapted based on student responses. Specifically, we analyzed two datasets: (1) An ordinal time-series dataset, where teacher questions and student responses were paired in chronological order; (2) A lagged time-series dataset, where the first teacher question was dropped and each remaining teacher question was matched to the prior student response. This approach allowed us to examine both how students adjusted their responses based on teacher question complexity, and whether teachers adjusted subsequent questions based on prior student performance. If there was a long time gap or an unrelated teaching activity between a response and a subsequent question (e.g., during group work or media playback), the pair was excluded from the analysis to ensure interpretive accuracy.

5. Results

5.1. The dominant pattern: closed question-short answer type

In response to RQ1, the analysis visually presents the overall patterns of question-and-answer interactions in all the classes of two teachers as shown in Figs. 1 and 2. In these figures, each dot in the grid represents a combination of a question and the corresponding answer. In these Figures, the horizontal axis represents the levels of teacher questions (0–3), abbreviated as "Tq", while the vertical axis represents the levels of student answers (0–3), abbreviated as "Sa". Overall, the classroom interactions of both teachers are concentrated in the closed-short question and answer pattern.

Following the analytical approach of Smit et al. (2022), this study identifies the most frequently occurring question and answer combination pattern in each class session as the attractor state. The statistical results from Tables 3 and 4 show that Teacher A asked an average of 88 closed questions per class session, accounting for 74 % of the total questions asked, while Teacher B asked an average of 41 closed questions per class session, accounting for 54.6 % of the total questions asked. Teacher A received an average of 67 short answers per class session, and Teacher B received an average of 41 short answers per class session. As shown in Table 4, the attractor state in all 12 class sessions is the closed-short question and answer pattern. These findings suggest that teacher-student dynamics are largely constrained to brief exchanges, particularly in response to closed questions, where students often offer minimal answers, as illustrated in Excerpt 2.

Excerpt 2 (Teacher B session 4).

教师: 如果你身边的女生说"你们男生以貌取人", 你觉得这是批评呢还是赞美呢?

Teacher: If a girl next to you says, 'You guys judge people by appearance,' do you think it's a criticism or a compliment?

学生: 我说批评。

Student: I would say it's a criticism.

Although the English translation appears longer, the original Chinese utterance "我说批评" is a short, non-elaborative phrase.

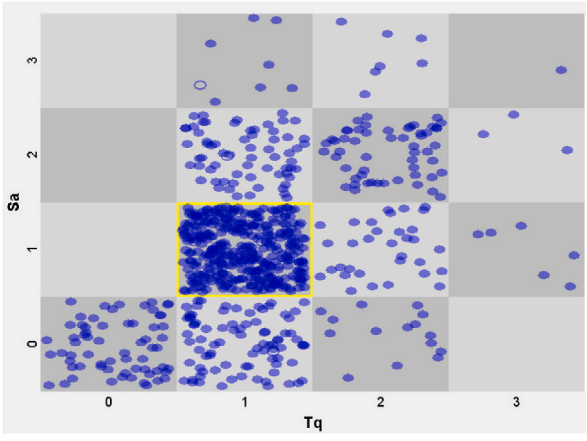

Fig. 1. Overview of the question-answer pattern in Teacher A's six class sessions.

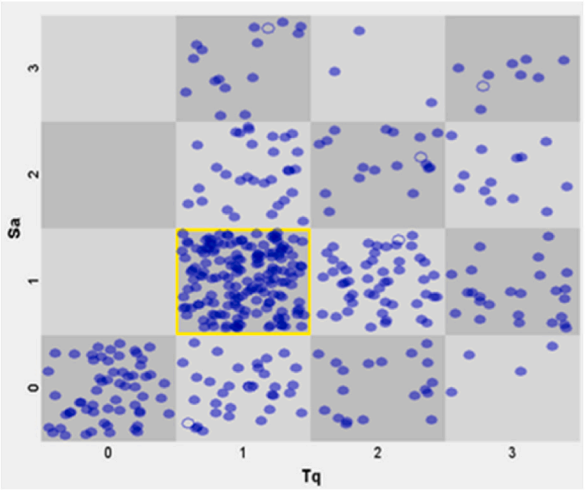

Fig. 2. Overview of the question-answer pattern in Teacher B's six class sessions.

Table 3
Descriptive statistical analysis results of class question and answer combinations.

Class	Closed questions	Short answers	Class	Closed questions	Short answers
A1	54	40	B1	32	52
A2	93	68	B2	29	25
A3	84	56	B3	79	98
A4	115	93	B4	38	32
A5	86	61	B5	48	39
A6	94	86	B6	22	26
A(average)	87.667	67.33	B (average)	41.33	40.5

Table 4
Descriptive statistical analysis results of class question and answer combinations.

Class	Q-A combination	Cell range	Attractor state	Attractor value(%)	Dispersion Coefficient
A1[a]	79	8	Closed-Short	48.1	.77
A2	118	9	Closed-Short	56.8	.679
A3	123	10	Closed-Short	36.6	.85
A4	135	7	Closed-Short	65.9	.569
A5	112	10	Closed-Short	49.1	.767
A6	144	10	Closed-Short	49.3	.772
A (average)	119	9	Closed-Short	50.1	.73
B1	52	8	Closed-Short	32.1	.858
B2	48	10	Closed-Short	49	.778
B3	151	13	Closed-Short	40.3	.853
B4	74	11	Closed-Short	32	.886
B5	80	10	Closed-Short	38.6	.825
B6	45	12	Closed-Short	34.8	.889
B (average)	75	10.667	Closed-Short	37	.848

[a] A1 represents the first lesson of Teacher A, B2 represents the second lesson of Teacher B, and so on.

According to our coding criteria, responses consisting of one to three words or sentence fragments without further explanation are classified as "simple answers." In this case, the teacher's closed question elicited a brief and subjective response from the student, without prompting elaboration or deeper reflection. This pattern, repeated across multiple interactions, reflects a limited scope for cognitive engagement.

Despite the predominance of closed questions, open-ended, real-life related questions accounted for approximately 2.1 % (15 out of 711) of all questions asked, occasionally leading to more elaborate responses. For example, when Teacher A asked students in Session 3, 如果断网三天,你做什么呢? (*If there were no internet for three days, what would you do?*), a student initially gave a short elaborative answer, 没有网络,没有办法上班,所以很麻烦 (*Without the internet, I wouldn't be able to work, so it's very troublesome*). In response, when the teacher followed up with, 为什么很麻烦? (*Why do you think it's very troublesome?*), the student elaborated with much detail, explaining: 因为如果你要跟朋友们商量在网络,我们常常用网络。如果你要看电影,在手机上用网络。如果是学习在晚上用网络。所以

现在没有网络很麻烦 (*Because if you need to talk to friends, we often use the internet. If you want to watch movies, you use the internet on your phone. And for studying at night, you also use the internet. So, without the internet, it's very troublesome*). This response showed a deeper engagement as the student connected the topic to various aspects of daily life, demonstrating how the teacher's questioning strategy encouraged the student to reflect on the essential role the internet plays in personal, social, and academic activities.

It is noteworthy that Table 4 shows considerable variability in dynamic changes across different class sessions compared to the average values of both teachers' classes. Teacher A's question-and-answer patterns fluctuated between 8 and 10 cells per session, indicating 8 to 10 types of question-and-answer combination instances. The attractor value of the closed-short question and answer pattern in Teacher A's classes ranged from 36.6 % to 65 %, with the dispersion coefficient fluctuating between .56 and .85. Teacher B's question-and-answer patterns fluctuated between 8 and 13 cells per session. The attractor value of the closed-short question-and-answer pattern ranged from 31.1 % to 45.8 %, with the dispersion coefficient between .778 and .889.

In sum, from the data in Tables 3 and 4, Teacher A's classes showed a concentrated interaction pattern overall (average cell range = 9, attractor value = 51 %, dispersion coefficient = .73), but individual sessions varied significantly, with attractor values from 36.6 % to 65 % and dispersion coefficients between .56 and .85. In contrast, Teacher B's classes exhibited higher dynamic variability (average cell range = 10.667, attractor value = 37 %, dispersion coefficient = .848), with most sessions having dispersion coefficients above .8. Additionally, the number of questions and answers varied significantly across sessions. For instance, session B3 had 151 question-and-answer interactions, the highest among the 12 sessions. This indicates significant variability in question-and-answer interactions across sessions, making it difficult to reflect the dynamic complexity of individual sessions by comparing only the overall patterns of the two teachers.

5.2. Characteristics of individual variations in question-and-answer interaction patterns

To explore the variability in teacher-student interaction patterns, due to space limitations, two sessions from each teacher were selected for display and reporting. We selected sessions A4 and A6 from Teacher A to contrast fixed versus adaptive interaction dynamics within the same teacher's classes. Additionally, A6 had the highest number of open-ended questions compared to other sessions with a similar cell range of 10 (A3 and A5). For Teacher B, we chose sessions B1 and B6, which shared similar statistical profiles but differed in the distribution and depth of interaction types.

Figs. 3 and 4 illustrate the interaction patterns in sessions A4 and A6, respectively, with lines connecting the transitions between events. In session A4, the most common pattern is the closed question and short answer, as noted in the highlighted cell of Fig. 3. The range of cells visited in the state space grid for session A4 is 7, the lowest among the 12 sessions. Teacher A predominantly used closed questions, while students typically provided no response or short answers. According to Table 4, A4 has the highest attractor value at 65.9 % and the lowest dispersion coefficient at .57, suggesting it has the least variability and the most fixed question-and-answer pattern of all sessions.

Fig. 4 shows that session A6 also has a closed question and short answer as the attractor state. However, compared to A4, A6 presents a more diverse and dynamic interaction pattern. In this session, the range of cells visited increased to 10. Although the teacher's questions are still concentrated in the closed type, there is an increase in explanatory questions and some open questions. SR are mainly short answers, but there is a significant increase in complete responses, and complex response levels also appear. According to Table 4, the attractor value for A6 is 49.3 %, and the dispersion coefficient is .772.

Figs. 5 and 6 reflect the question-and-answer patterns in Teacher B's first and sixth sessions (B1 and B6). The attractor values for B1 and B6 (34.6 % and 33.3 %) and the dispersion coefficients (.858 and .889) are similar, indicating that the variability in question-and-answer patterns for these sessions is comparable and relatively high among the 12 sessions. However, the state space grid distribution shows that B1 had 8 cells visited, with the question-and-answer patterns concentrated in the lower two layers of the grid, indicating that the teacher's questions often received no response or only short responses, mainly consisting of closed and explanatory questions.

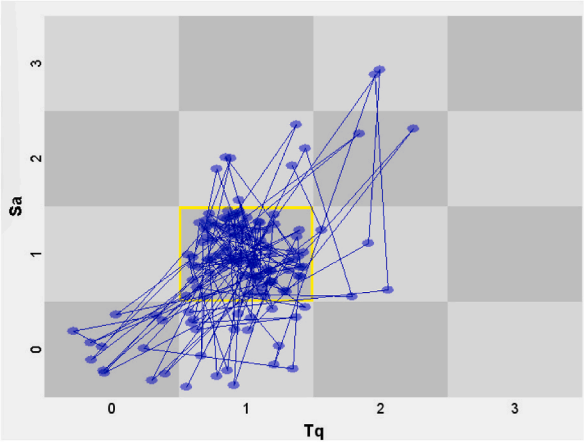

Fig. 3. Variation in question-answer patterns for Session A4.

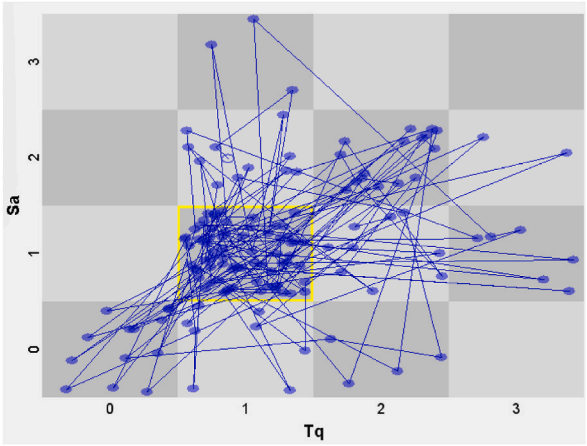

Fig. 4. Variation in question-answer patterns for Session A6.

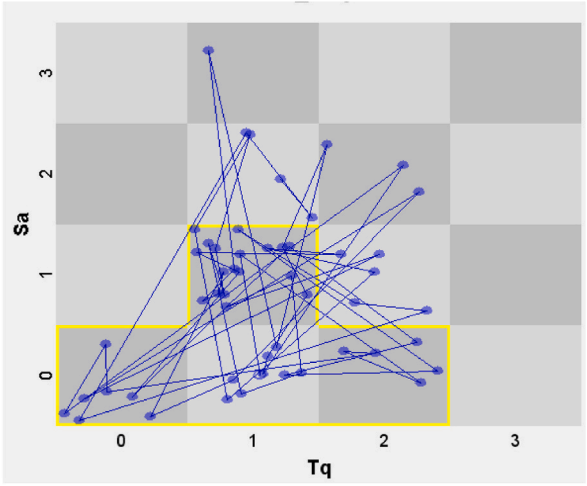

Fig. 5. Variation in question-answer pattern for session B1.

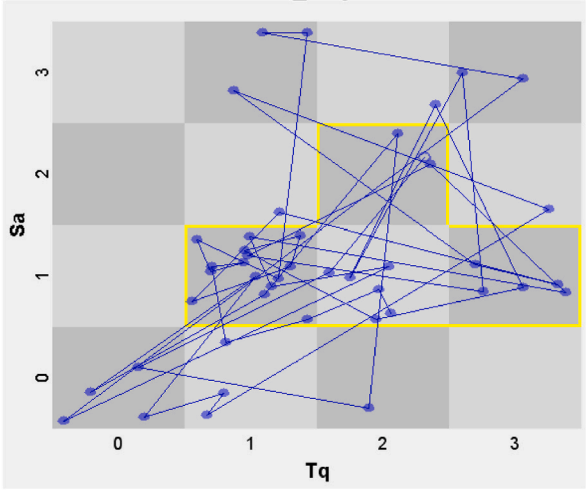

Fig. 6. Variation in question-answer pattern for session B6.

In contrast, B6 had 12 cells visited, with the question-and-answer patterns concentrated in the second layer, indicating a decrease in no responses, though short responses remained predominant. Compared to B1, session B6 saw an increase in open questions. For example, in Session 6, a meaningful engagement arose when Teacher B asked a student about her family customs: 你回国见到爸爸妈妈,你们用什么方式表达亲密呢? (*When you return home and meet your parents, how do you express closeness?*). Initially, the student responded, 我哭,老师。我肯定是 (*I would cry, teacher, definitely*). As the teacher probed further with 会拥抱吗?你们国家是拥抱吗? (*Would you hug? Is hugging common in your country?*), the student provided a more elaborate answer: 我们拥抱,还会摸爸爸妈妈的脚,这是我们的一种敬拜,在我们国家,我每天出门时也会这样,就是摸脚和祝福 (*We hug, and we touch our parents' feet as a form of worship, in our country, I would do this every day when I leave home. It's touching the feet and blessing*). This exchange highlighted the role of culturally grounded questions in eliciting rich, detailed responses.

To further explore the variability in teacher interaction styles, a preliminary analysis was also carried out to probe into the differences in question techniques and their potential impact on student responses. It was observed that Teacher A predominantly relied on textbook-driven methods, focusing on exercises such as sentence-making, fill-in-the-blank activities, and vocabulary explanations. This led to a greater reliance on closed questions and predetermined answers, limiting opportunities for diverse responses. In contrast, Teacher B adopted a slightly more thematic approach, integrating language points from the textbook into interactive activities such as group discussions and collaborative exercises. This method encouraged a wider range of student responses and fostered a more dynamic and engaged learning environment.

Overall, closed questions and short answers dominate the classroom interactions of both teachers, with teachers' questions often receiving no response from students. Additionally, it is worth noting that certain specific types of questions from the teacher can elicit responses of different levels, indicating a discrepancy between the expected answers from the teacher and the actual answers from the students.

5.3. Relationship between teacher question levels and student answer levels

To further investigate the co-adaptation between teacher questions and student answers, a correlation analysis was conducted on two datasets: ordinal and lagged time-series. The ordinal time-series dataset arranges teacher questions and corresponding student answers in chronological order. The lagged time-series dataset removes the first teacher question, shifts the remaining questions up sequentially, and removes the last student response. The left column of Table 5 shows the Spearman correlation coefficients for the ordinal time-series dataset, reflecting the correlation between teacher question types and subsequent student answer types. The right column shows the Spearman correlation coefficients for the lagged time-series dataset, reflecting the correlation between teacher question types and prior student answer levels.

The statistical results for the ordinal time-series dataset show a significant correlation between the levels of teacher question and student answer across the 12 lessons, as indicated in the left column of Table 5. The correlation coefficients are all positive, ranging from .27 to .62, indicating a weak to moderate correlation between teacher question and student answer. This suggests that students adjusted their answer levels according to the complexity of the teacher questions. Excerpt 3 demonstrates this moderate correlation:

Excerpt 3 (Teacher B, Session 3).

教师:你说你很喜欢游泳,对吗?

Teacher: You said you like swinging very much, right?

学生:对.

Student: Yes.

教师:那在你们国家游泳迷怎么样?很多?

Teacher: So, what about the swimming fan in your country? Are there many?

学生: 是,在我们的国家, 我们的国家有很多游泳迷。

Student: Yes, in our country, our country has many swimming fans.

教师:嗯,有很多游泳迷,然后呢?

Table 5
Statistical analysis of teacher-student question and answer relationships.

Class	Ordinal Time-Series Results		Lagged Time-Series Results	
	Spearman's Correlation Coefficient	p value	Spearman's Correlation Coefficient	p value
A1	.536	.000	.039	.738
A2	.623	.000	.081	.384
A3	.294	.001	.090	.322
A4	.562	.000	.073	.404
A5	.528	.000	.126	.188
A6	.457	.000	−.117	.163
B1	.274	.049	−.152	.286
B2	.516	.000	−.084	.574
B3	.352	.000	.102	.216
B4	.318	.006	−.077	.519
B5	.578	.000	.091	.424
B6	.430	.003	.088	.576

Teacher: um, many swimming fans, so then?

学生:嗯,在我的国家,从小时候到老人还是年轻人,他们每天都去海边游泳,我们的国家很多,很多海洋，…大部分在越南,很多人都,都会游泳。

Student: um, in my country, from childhood to old people or young people, they go to the seaside to swim every day, our country has a lot, a lot of oceans … most in Vietnam, many people, will swim.

In this example, there is a weak to moderate correlation between the teacher's questions and the student's responses. Teacher B begins with a level 1 closed question, prompting a brief level 1 response from the student. The follow-up question is more complex, at level 2, and the student's answer similarly becomes more elaborative, though still moderate in depth, indicating a level 2 response. Finally, the teacher poses an open-ended continuation question at level 3, prompting the student to provide a more detailed response. This demonstrates how the student adjusted their response level to match the increasing complexity of the questions, highlighting a moderate correlation between the teacher's questions and the depth of the student's answers.

In contrast, the correlation analysis for the lagged time-series dataset suggests a slight correlation between student answers and subsequent teacher questions, though none of these correlations reached statistical significance. This finding possibly indicates that teachers may not have consistently adjusted the complexity of their questions based on students' prior answers. Excerpt 4 below illustrates a potential misalignment between question complexity and student responses.

Excerpt 4 (Teacher A, session 5):

教师: 明珠,你怎么样?你还很忙吗?

Teacher: Mingzhu, how are you, are you still very busy?

学生:每个星期一和星期二很忙。因为星期天我没有工作,因为公司放假。

Student: Every Monday and Tuesday I am very busy. Because I don't work on Sundays, because the company is on holiday.

教师: 就是每个星期一和星期二是最忙的。因为周末不上班,对吗?

Teacher: So, every Monday and Tuesday are the busiest. Because no work on weekends, right?

学生: 对对。

Student: Right, right.

教师: 工作都集中到了星期一和星期二。没事,你忙吧。

Teacher: Work is all piled up on Monday and Tuesday. It's okay, you be busy.

In this interaction, Teacher A started with a mix of level 1 and level 2 questions. The student provided a detailed level 3 answer. However, Teacher A then summarized the response and asked a simple level 1 question, which led to a brief student answer. The teacher closed the conversation by repeating the student's earlier answers, missing an opportunity to pose more complex questions. This shows that the teacher's questions did not increase in complexity to encourage more advanced student answers.

Nevertheless, there are occasions when teachers appeared to engage students more deeply by eliciting input based on the situational context and responding to their linguistic and communicative capabilities. By framing their questions to encourage elaboration, teachers fostered richer discussions that validated students' experiences and challenged them to articulate their thoughts. For example, during a discussion about the concept of 可爱 (cute) related to finding boyfriends, Teacher A asked what qualities students preferred. One female student responded, 他应该可爱 (He should be cute), surprising the teacher. When Teacher A followed up with, 你是说女生可爱,对吧? (You mean girls are cute, right?), the same student expanded her point: 不,我是说男生也可爱 (No, I mean boys can be cute too). This prompted another female student to add, 可是我觉得,如果男生可爱,那就像女生一样,不能保护我 (But I think if a boy is cute, it's like he's a girl and can't protect me). This exchange illustrates how teacher-student interactions can possibly prompt students to articulate their understanding of concepts in their own words and engage with differing perspectives. However, the data does not provide direct evidence of the teacher's intent behind the follow-up question. While we cannot definitively determine the teacher's intent, this exchange suggests that open-ended questioning can promote deeper engagement. Further research is needed to explore the underlying factors that contribute to such interactions.

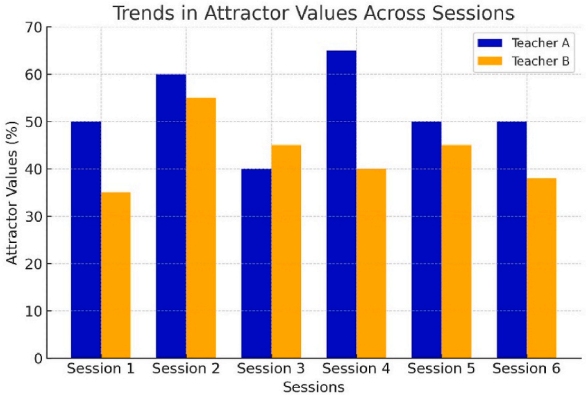

Fig. 7. The attractor value of all teaching sessions.

5.4. Trends in attractor values and their underlying causes

Figs. 7 and 8 illustrate the trends in attractor values for closed-short question-and-answer patterns and dispersion coefficients across six teaching sessions for Teacher A and Teacher B. Overall, Teacher A's lessons exhibit higher attractor states and lower dispersion coefficients compared to Teacher B's. These trends, when analyzed alongside the lesson summaries in Table 1, suggest that variations in learning activities may possibly influence the stability and variability of question-and-answer patterns.

In particular, Session 3 demonstrates the lowest attractor value and highest dispersion coefficient among Teacher A's sessions, indicating a greater diversity in interaction patterns. This session incorporated two distinct activities: (1) guiding students in a discussion on online activities, which was based on a post-text activity, and (2) facilitating a fill-in-the-blank exercise. Compared to her other sessions, this lesson featured increased student engagement and a higher occurrence of open-ended questions, encouraging more elaborate student responses.

For example, during the fill-in-the-blank exercise, students were prompted to complete the sentence: *The internet allows me to* _____. This activity encouraged them to generate personalized responses, leading to more variation in their language use:

[00:28:25.20] Teacher A: What does the internet allow me to do? (网络让我怎么样了?)

[00:28:27.28] S4: To chat with friends. (嗯,跟朋友聊天。)

[00:29:25.22] Teacher A: S5, what's your answer? (S5, 你的句子呢?)

[00:29:32.11] S5: The internet allows me to study well. (网络让我好好儿上课。)

In contrast, Session 4 exhibits the highest attractor value and lowest dispersion coefficient, reflecting a more rigid interaction pattern. This session was predominantly textbook-focused, with vocabulary and text instruction relying heavily on closed questions. For instance:

[00:42:07.04] Teacher A: Do you understand the meaning of "cuoguo"? (大家明白 "错过" 的意思吗?)

[00:42:10.22] Ss: Understand. (明白。)

[00:42:15.23] Teacher A: Good. (好的。)

Teacher B, on the other hand, consistently integrated discussion-based activities, which likely contributed to her lower attractor values for closed-short question patterns. This approach fostered more dynamic interactions but resulted in less stability compared to Teacher A's structured sessions.

5.5. The possible impact of class size on interaction patterns

Regarding the class size imbalance highlighted in the methodology, this study examined its potential impact on interaction patterns, focusing on the frequency of "non-response" questions. These refer to instances where the teacher asked questions requiring student responses, but no answers were provided due to hesitation, lack of knowledge, or disengagement. The non-response rate was chosen for comparison because, while interactive patterns and teacher-session variations were analyzed earlier, it offers a clear indicator of how class size imbalance may affect participation, challenging the assumption that smaller classes naturally foster engagement.

Surprisingly, the overall non-response rate was higher in the small classes (14.4 %) than in the large classes (8.8 %). This difference seems to stem from contrasting questioning strategies. In the small classes, 46.3 % of non-response questions were directed to the whole group (e.g., "Who is ready to answer this?"), relying on voluntary participation. By comparison, only 15.8 % of such questions in the large classes were group-directed, with some sessions having none. The teacher in the large classes tended to target individual students directly, likely reducing non-responses through accountability. In contrast, the teacher in the small classes may have assumed the intimate setting encouraged engagement, relying more on open prompts. However, this may have increased non-responses due to diffusion of responsibility, where students expected peers to respond.

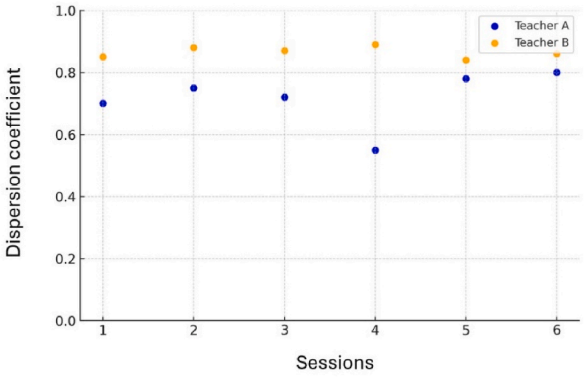

Fig. 8. The dispersion coefficient of all teaching sessions.

6. Discussion

6.1. The attractor state and dynamics of teacher-student question-answer patterns

From the perspective of CDST, this study conducted an exploratory analysis of the dynamic changes in the question-and-answer patterns between teachers and students in online Chinese speaking classes. State space grids were employed to capture the micro-dynamic changes of the complex dynamics in the classroom questioning patterns. The results showed that these 12 classes were predominantly characterized by closed questions with short answers, indicating that this pattern had a strong attractor effect on teacher-student interactions. The dominant pattern may be influenced by the structured nature of online teaching platforms, which often facilitate more controlled interactions compared to physical classrooms (Shi & Stickler, 2018).

Closed questions, while useful for maintaining class pace and controlling interaction, have both advantages and drawbacks, as evidenced by existing literature. For instance, Hu (2021) notes that closed questions quickly check learners' understanding, ensuring smooth communication, particularly when internet stability is an issue. They require fewer cognitive resources and simpler linguistic responses, resulting in short, direct answers (Smit et al., 2022). However, as Waring (2012) points out, closed questions, especially yes/no types, limit elaboration, potentially hindering skill development and reducing engagement, leading to boredom (Jin, 2018). Our data, shown in Figs. 1–6, revealed that students often gave no answer, causing teachers to ask more questions, which can lead to frustration for both teachers and students. Teachers may feel discouraged by repeated breakdowns in interaction, while students may experience increased pressure or disengagement, especially when unable to formulate answers quickly in the online setting. This supports Hill and Flynn's (2008) observation that the type of questions significantly affects student answers. Thus, while closed questions are beneficial, teachers should consider adjusting their complexity to stimulate thinking and increase engagement, balancing classroom control with cognitive development.

6.2. The intra-teacher and inter-teacher variances between the two teachers' interaction patterns and across lessons

Overall, the two teachers' question-and-answer interaction patterns exhibited distinct differences, which can be attributed to variations in their teaching methods and content. Teacher A's interaction pattern was more concentrated and less flexible than Teacher B's, reflecting the impact of different pedagogical approaches. This observation aligns with Walsh's (2011) findings that classroom questioning patterns were influenced by factors such as teaching materials, classroom management, skill objectives, and classroom atmosphere. Although both teachers instructed intermediate Chinese speaking classes to parallel classes from the same department using the same textbook, the contrasting approaches of Teacher A and Teacher B highlight fundamental differences in teaching philosophies that significantly shape classroom interactions and learning outcomes.

Teacher A's reliance on a textbook-driven methodology, which emphasized structured activities like sentence-making and fill-in-the-blank exercises, aligns with traditional language teaching practices that prioritize accuracy and the mastery of specific forms. While this method provides clear, measurable outcomes, it inherently limits student agency by focusing on convergent thinking, where there is typically one correct answer. This echoes earlier critiques of structured teaching (Long & Sato, 1983), which often result in superficial student engagement and a lack of deeper cognitive processing.

In contrast, Teacher B's use of thematic, discussion-based activities encourages divergent thinking, allowing students to generate multiple answers and connect language learning to broader, meaningful contexts. This approach fosters a more student-centered environment that supports autonomy, engagement, and the negotiation of meaning, which is essential for language acquisition (Larsen-Freeman, 2008). Thematic teaching also integrates language skills holistically, promoting not only linguistic competence but also cognitive and social skills, as evidenced by the diverse responses elicited during group discussions and debates.

Moreover, the differences in questioning strategies observed between the two teachers may be partly influenced by their backgrounds and teaching experience. Teacher B's extensive experience in teaching oral Chinese, both in China and internationally, along with her authorship of language textbooks, may have contributed to her ability to engage students through dynamic, discussion-based questioning that fosters divergent thinking. In contrast, Teacher A, with a stronger focus on literature and cultural studies, appeared less skillful in facilitating interactive oral practice. However, this inference should be made with caution, as our study does not explicitly examine the factors influencing teaching strategies. Rather, it focuses on the fundamental patterns of teacher-student questioning within the CDST framework. Future research could explore these factors further through qualitative methods, such as interviews with teachers and students.

In addition to overall differences in the two teachers' question-and-answer patterns, state space grids reveal the dynamics and variability of questioning patterns in each class. CDST posits that systems, even in stable attractor states, are continuously changing. This means the dominant pattern of classroom interaction is not static but in different stages of variability. While the closed-question and short-answer pattern has a strong attractor effect in all classes studied, each class shows unique distributions and dynamics of teacher-student interaction within the state space grid.

6.3. The co-adaptability of teacher-student question-answer patterns

While flexible teacher-student interaction patterns indicate classroom co-adaptability, they don't guarantee successful mutual adaptation. Consistent with Smit et al. (2022), the study found that learners adjusted their responses to the types of questions, but teachers often failed to adjust their questions based on student answers. This suggests that while teacher questioning fosters interaction, the question type significantly impacts the depth of student answers (Hill & Flynn, 2008). Closed questions increase response

rates and reduce silence, but they limit the complexity and diversity of learner answers.

From a CDST perspective, classroom interaction is understood as a process of mutual adaptation, where teachers must recognize learners' intentions and adjust questions accordingly. Video observations showed that teachers often ended exchanges by repeating learners' answers with yes/no questions. To encourage deeper thinking and more complex responses, teachers could improve question openness (Larsen-Freeman, 2008). However, fully adaptive teaching is challenging, as it requires continuous monitoring of learners' cognition, emotions, and classroom atmosphere, with real-time adjustments. Interaction delays in online classrooms due to unstable internet connections further complicate this process, though this impact is beyond the scope of this study.

Interestingly, the study also found that the same type of questions by teachers can lead to varying degrees of interaction. For instance, open questions do not always elicit complex answers from learners and sometimes result in no response at all. Conversely, closed questions can sometimes prompt complete and complex responses from learners. Therefore, the level of questioning is not necessarily the higher the better; teachers should adjust the level of questions based on learners' responses during questioning.

Lastly, a notable finding in this study is the similarity between our results and those of Smit et al. (2022), despite the different contexts—this study in an online environment and theirs in physical classrooms. This may imply that effective questioning strategies remain a consistent challenge for teachers across both settings, highlighting the need for more focused training on adaptive techniques. Additionally, the dominant closed question-short answer pattern observed in this study may reflect a broader issue highlighted by Shi and Stickler (2018), Heins et al. (2007), and Hu (2021): the unique nature of online learning environments, with their structured and controlled interactions, likely plays a significant role in shaping question-answer dynamics. Therefore, exploring ways to improve question-answer dynamics and deepen cognitive and linguistic engagement remains an important area for future research.

7. Conclusion, implications, and limitations

This study analyzed the dominant patterns, dynamics, and co-adaptive relationships of question-and-answer interactions in 12 online intermediate Chinese-speaking lessons. The key findings revealed that closed questions and short answers predominated in classroom interactions, limiting opportunities for deeper cognitive engagement. Notably, significant differences in questioning patterns were observed between the two teachers, with Teacher B's more interactive approach generating varied and complex student responses.

These findings have important pedagogical implications for online Chinese language education. First, teachers should diversify their questioning techniques. Rather than predominantly using closed questions, incorporating more open-ended questions encourages students to elaborate and reflect more deeply on the material. Asking students to explain concepts in their own words or relate questions to their real-life experiences and cultural practices can promote greater cognitive engagement and enrich classroom discussions.

Additionally, teachers must adapt their questioning strategies based on student responses. Teacher training programs should emphasize this adaptability, teaching educators to recognize when a response requires further probing or a follow-up with an open-ended question. Such adaptive teaching can create a dynamic classroom environment, fostering active student participation and deeper engagement with the material.

Incorporating interactive activities—like group discussions, debates, and collaborative projects—is another effective way to enhance student engagement. These activities encourage diverse responses and critical thinking, leading to a more collaborative learning environment. Online platforms like Zoom can utilize breakout rooms to facilitate small group tasks, allowing focused peer interaction that encourages active participation and deeper material engagement. Teachers can also encourage students to ask questions in these smaller groups, which may reduce pressure during teacher-led questioning and foster relaxed, peer-centered exchanges. Moreover, personalized questioning that relates to students' experiences or interests tends to elicit more thoughtful responses, increasing engagement and building rapport between teachers and students, thereby enhancing the learning environment.

Despite the study's contributions, certain limitations should be noted. The findings are based on a small sample of 23 students from specific linguistic and cultural backgrounds, which may limit generalizability. Additionally, the unique challenges of the online environment, such as the absence of non-verbal cues, may have influenced the observed interaction patterns, which could differ in physical classrooms.

Future research should explore how online and offline classrooms affect teacher-student interaction patterns, particularly focusing on non-verbal cues such as gestures, facial expressions, and gaze direction. A mixed-method approach, combining quantitative data and qualitative insights from interviews with teachers and students, would deepen understanding of questioning strategies and student perceptions of their response abilities, offering practical insights for enhancing teacher-student interactions in both contexts.

Incorporating multimodal analysis—examining both verbal exchanges and non-verbal communication—would provide a comprehensive view of classroom dynamics, especially in online settings where non-verbal cues are less visible. Additionally, a longitudinal approach could track how interaction patterns evolve over time, assessing whether teachers become more adaptive in their questioning strategies as they become familiar with their students and the online medium.

Additionally, while it is important for teachers to adapt their questioning strategies based on student responses, this is no easy matter. Effective adaptation requires teachers to balance cognitive demands on students with the goal of fostering deeper engagement. Teacher training programs may want to emphasize the complexity of discourse production, which involves a sequential process of generating content, processing semantic input, encoding it in vocabulary and syntax, and producing perceivable speech. To support this, training might focus on practical strategies such as breaking down questions into smaller, manageable steps. For example, instead of asking a direct yes/no question like 'Do you like Chinese food?', teachers could use guided questions like 'Where do you usually eat after class?', 'What kind of dishes are there?', and 'Which ones do you like?' These incremental steps allow students to build confidence

and motivation while gradually preparing them for more complex, structured responses.

Lastly, the findings highlight the need to tailor questioning strategies to class size. In small classes, teachers should balance open questions with direct prompts to encourage engagement while minimizing non-responses. In large classes, incorporating voluntary responses alongside targeted questioning fosters autonomy and inclusion. Small classes support personalized learning, while large classes benefit from structured participation. Teacher training should integrate these insights to enhance questioning techniques and optimize student engagement.

CRediT authorship contribution statement

Huan Huang: Writing – original draft, Formal analysis, Conceptualization. **Michael Li:** Writing – review & editing, Validation, Methodology. **Chujie Dai:** Writing – original draft, Methodology, Conceptualization.

Funding

This work was supported by Shantou University, China, STU Scientific Research Initiation Grant: [grant number STF24008T].

Acknowledgments

We would like to thank the editors of System for their invaluable support, as well as the anonymous reviewers for their invaluable feedback and suggestions given on the early versions of this article. Their critical evaluation and detailed comments have greatly contributed to shaping our manuscript and improving its quality.

R.eferences

Chen, Z. (2021). Investigating teachers' questioning in second language acquisition based on SETT framework. *IOP Conference Series: Earth and Environmental Science, 692*(2), 22–55. IOP Publishing.

de Bot, K., Lowie, W., & Verspoor, M. (2007). A dynamic systems theory approach to second language acquisition. *Bilingualism: Language and Cognition, 10*(1), 7–21.

Derksen, M., & Morawski, J. (2022). Kinds of replication: Examining the meanings of "conceptual replication" and "direct replication. *Perspectives on Psychological Science, 17*(5), 1490–1505.

Gibbons, P. (2002). Scaffolding language, scaffolding learning: Teaching second language learners in the mainstream classroom. *Portsmouth*. NH: Heinemann.

Heins, B., Spiro, J., & Curnow, T. J. (2007). Spoken interaction in online and face-to-face language tutorials. *Computer Assisted Language Learning, 20*(3), 279–295.

Hill, J. D., & Flynn, K. (2008). Asking the right questions. *The Learning Professional, 29*(1), 46–52.

Hollenstein, T. (2013). *State space grids: Depicting dynamics across development*. New York: Springer.

Hu, X. (2021). A comparative study of teaching questions in the synchronous online TCFL and offline TCFL and the in-class time loss. *Journal of Yunnan Normal University (Teaching and Research on Chinese as a Foreign Language Edition), 19*(2), 56–64.

Inquirium, L. L. C. (2020). InqScribe [Computer software] Version 2.2. https://www.inqscribe.com.

Jin, H. (2017). Roles of pushed output in second language acquisition and second language instruction. *Chinese Teaching in the World, 4*, 510–541.

Jin, H. (2018). An interactive approach to teacher's questions: Theories and practices. *International Chinese Language Education, 1*(2), 46–62.

Larsen-Freeman, D. (2022). A complex dynamic systems perspective to researching language classroom dynamics. In *Research questions in language education and applied linguistics: A reference guide* (pp. 793–798). Cham: Springer International Publishing.

Larsen-Freeman, D., & Cameron, L. (2008). *Complex systems and applied linguistics*. Oxford: Oxford University Press.

Liu, J. (2016). Application of the questioning teaching method: A case study of the kunming-based advanced Chinese program of Duke University. *Journal of Yunnan Normal University (Teaching and Research on Chinese as a Foreign Language Edition), 14*(3), 45–52.

Long, M. H., & Sato, C. J. (1983). Classroom foreigner talk discourse: Forms and functions of teachers' questions. In H. W. Seliger, & M. H. Long (Eds.), *Classroom oriented research in second language acquisition* (pp. 253–279). Massachusetts: Newbury House.

McNeil, L. (2012). Using talk to scaffold referential questions for English language learners. *Teaching and Teacher Education, 28*(3), 396–404.

Moorhouse, B. L., Li, Y., & Walsh, S. (2023). E-classroom interactional competencies: Mediating and assisting language learning during synchronous online lessons. *RELC Journal, 54*(1), 114–128.

Qi, H., & Du, Z. (2008). Strategies of teachers' questioning in teaching Chinese as a second language at the intermediate level. *Chinese Language Learning, 5*, 86–92.

Qi, H., & Li, W. (2009). Interaction model of classroom discourse of PIB. *Journal of Beijing Normal University (Social Sciences), 6*, 111–118.

Richards, J. C., & Lockhart, C. (2007). *Reflective teaching in second language classrooms* (15th ed.). Cambridge University Press.

Seedhouse, P. (2010). Locusts, snowflakes and recasts: Complexity theory and spoken interaction. *Classroom Discourse, 1*(1), 4–24.

Şeker, H., & Kömür, S. (2008). The relationship between critical thinking skills and in-class questioning behaviours of English language teaching students. *European journal of teacher education, 31*(4), 389–402.

Shi, L., & Stickler, U. (2018). Interaction patterns in synchronous Chinese tutorials. *Innovation in Language Learning and Teaching, 12*(1), 6–23.

Smit, N., van Tartwijk, J., & Wubbels, T. (2022). The complex dynamics of adaptive teaching: Observing teacher-student interaction in the language classroom. *International Review of Applied Linguistics in Language Teaching, 60*(1), 23–40.

Song, Y. D. (2009). Strategies on teaching tones in Chinese as a foreign language. *Language Teaching and Linguistic Studies, 3*, 48–53.

van Dijk, M., Lowie, W., Smit, N., Verspoor, M., & van Geert, P. (2024). Complex dynamic systems theory as a foundation for process-oriented research on second language development. *Second Language Research, 0*(0).

Walsh, S. (2011). *Exploring classroom discourse: Language in action*. Routledge.

Waring, H. Z. (2012). Yes-no questions that convey a critical stance in the language classroom. *Language and Education, 26*(5), 451–469.

White, J., & Lightbown, P. (1984). Asking and answering in ESL classes. *Canadian Modern Language Review, 40*, 288–344.

Xia, S. (2020). Developing awareness of questioning strategies for second language learner teachers. *Journal of Language Teaching and Research, 11*(6), 853–862.

Yang, X. (2021). How can EFL teachers make their questions more interactive with students? Interpersonal patterns of teacher questions. *System (Linköping), 99*, Article 102509.

Zhang, D., Zhao, S., & Goh, H. H. (2009). Teacher questioning and construction of opportunities for Chinese language learning. *Journal of the Chinese Language Teachers Association, 44*(2), 81–101.